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FRANKLIN INSTITUTE,

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

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ELECTRICAL SECTION.

Stated meeting held Thursday, October 9, 1902.

Safe and Accurate Electric Safety Fuses.

Their Evolution, Principle, Operation and Application.

BY JOSEPH SACHS, M.A.I.E.E.

EXCESS-CURRENT PROTECTION.

Wherever electrical energy is expended upon a conducting medium heat, mechanical motion or chemical change are resulting manifestations. The conducting medium or apparatus, having a definite working capacity, it becomes necessary to limit the energy impressed upon it, so that the consequent heat, motion or chemical activity shall not exceed the safety limit. Injurious effects due to the excessive heat-development in conductors or the damaging results of sparking at commutating mechanism are dependent upon the rate of transformation. The impressed power and the time of its duration enter as direct functions. Injury from excessive mechanical strains and chemical changes are per-

haps more dependent upon the rate of change from the normal to the abnormal condition as well as upon the amount and duration of the injurious effects.

Two excess current conditions are generally considered: "overload" and "short circuit." These are but extremes of the same abnormal effect, due to either decreased impedance in the entire circuit acted upon by the impressed E.M.F. or to an abnormal rise in E.M.F. Overloads require an appreciable time to affect the apparatus injuriously, whereas, in the case of short circuits, the instantaneous development and large amount of electrical energy thrust upon the circuit almost eliminates any consideration of time as a function in the resulting effect. Great injury also results from a practically instantaneous rupture of an electrical circuit and the consequent momentary rise in potential due to inductive and capacity effects. It is of the utmost importance that the cessation of current flux should not take an instantaneous drop, but should rather slant off, even though the interval for such gradual rupture be exceedingly small. Excess current protective devices should be based upon these considerations. Their overload characteristics should be similar to those of the device protected.

There are two types of safety devices used in practical electrical work — the one is based upon the transformation of electricity into heat energy, and the other on the mechanical energy developed or released by the magnetic effect of the current. The vast multitude of protective devices are of the former type, the latter having found particular application where the matter of cost, mechanical complexity and other obvious deficiencies could be relegated to a secondary consideration, as compared with their advantages. Thermal safety protective devices, or fuses, aside from their mere simplicity have, however, inherent features which are probably the cause of the enormous use to which they have been put.

Three elementary requirements may be given for all practical excess current protective devices, as follows:

(1) Definite, unchangeable maximum continuous running current-carrying capacity.

(2) Definite energy overload capacity, depending inversely on the overload, and adjusted, with the allowance of a reasonable safety factor, to the apparatus protected. Like the apparatus protected, the safety device should be uninjured by a momentary overload of shorter duration than the time interval causing injury. The factor of safety should be less than in the device protected. Its operative principle should cause it to act instantaneously on short circuit and in a time inversely dependent on the amount of ordinary overload.

(3) Safe rupture operation. No device is universally safe unless the arc and explosive effect, ccincident with the rupturing of the circuit under any condition for which it is intended, is entirely suppressed or eliminated. It should not only prevent damage to extraneous devices, but should also be non-destructive to all connected parts other than those directly operative.

SAFETY FUSES.

The writer hopes he may take for granted the fact that the shortcomings of the old air-exposed fuse wire or strip, be it of lead-tin or alloy, copper, aluminum or possibly a hairpin, as has frequently been found the case by the electrical inspector, is beset with evils which scarcely require additional notoriety. Electrical engineers have learned that safety and accuracy in devices intended as a safeguard imply more than a mère opening of the circuit and the discontinuance of the current. Experience, in its usual expensive manner, has demonstrated the necessity of eliminating destructive arcing and the many variable factors which are inherent adjuncts in all exposed fuse devices. The elimination of arcing from fuse protective devices has proven a prolific field for the enlargement of the patent office receipts. It may be said, with credit to the majority of inventors of such devices, that a multitude of them have found practical application. Nearly all of these improvements, however, are in the direction of arc blow-out or checking arrangements. Only within the last five years has the very simple arrangement, known as an enclosed fuse, been constructed,

so that the arc, as we know it in the open air, really never exists. As a competing device, with its much cheaper, and perhaps, it may even be said, simpler predecessor, it has had to overcome the prime objection of increased cost; but judging from commercial results, enclosed fuses have unquestionably come to stay, and will eventually supplant the air-exposed devices.

Among the earliest attempts, a favored arrangement to prevent the continuance of destructive arcing and the spat-

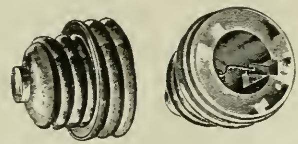


FIG. 1.—Edison fuse plug

FIG. 3.—Soft rubber tube fuses.

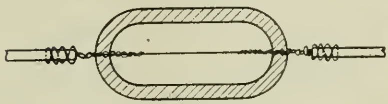


FIG. 2.—Edison enclosed fuse. Patent of May 4, 1880.

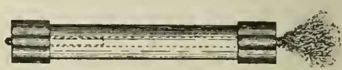


FIG. 4.—Fuse in center of close fitting insulating cylinder.

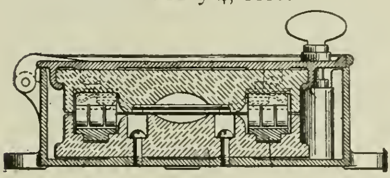


FIG. 5.—Fuse encased between two insulating blocks.

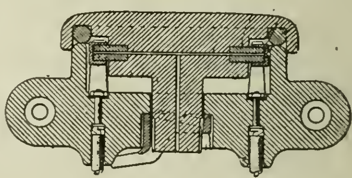


FIG. 6. -Fuse in centrally vented holder.

PLATE A, FIGS. 1–6.—Early enclosed fuses.

tering of molten metal consisted in encasing the fuse conductor in a tube or jacket of some insulating substance, as exemplified in the patent to Edison, May, 1880. Such mere jacketing under severe conditions of excess-current rupture results either in the sudden and forcible expulsion of flaming metallic vapors at the ends of the tube or casing if open, or, as in the case of the well-known Edison plug, or similarly arranged encased fuses, in the bursting or burning of the metallic cap, and frequently in the destruction of the entire

device. Glass, fiber or other insulating casings surrounding the fuse strip, and enclosing an appreciable amount of air, are arrangements which have found continued favor (see *Figs. 1, 2, 3, 4, 5, 6*). The results of rupture are shown in *Figs. 7, 8, 9, 10.*

The present enclosed fuse consists of an insulating tube encasing the fuse strip and a so-called filling material. The

FIG. 7.—Air-filled, 500 volts.

FIG. 8.—Solid wood cylinder.

FIG. 9.—Solid wrapped asbestos.

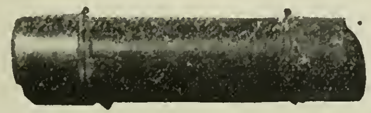


FIG. 10.—Air-filled, 220 volts.

PLATE B.—Rupture results air-filled and solid case fuses.

latter is usually a finely divided insulating powder, and occupies all, or the larger part of the space within the tube. Its function is to prevent the formation and maintenance of any arc upon rupture of the wire, and also to fix the several variable factors affecting the carrying capacity and melting of the strip. The ends are closed with caps or ferrules which act as circuit terminals, or from which the circuit terminals

project, and the combination thus forms a self-contained composite fuse structure. Some years ago the mechanical arrangement of the filling about the fuse wire received a great deal of attention. Some manufacturers deemed it essential to place it so as to leave a portion of the wire, preferably a short length, at the center, surrounded by an air space (see *Figs. 11, 12, 13*). Later product, however, shows that the air space has been dispensed with, and at the present time it may be stated that the great majority of enclosed fuse devices simply have a powder completely surrounding

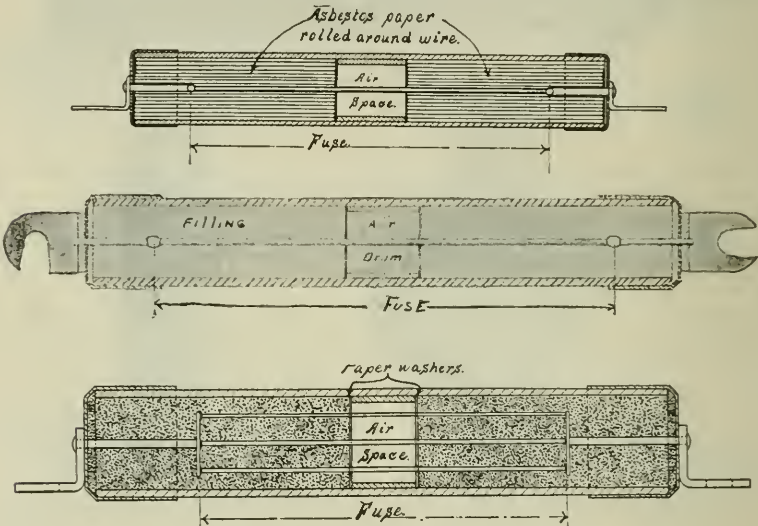


PLATE C, FIGS. 11, 12, 13.—Air-space fuses.

the wire, filling the entire space within the tube. The writer, in a paper presented before the A.I.E.E., entitled "The Evolution of Safe and Accurate Fuse Protective Devices," endeavored to show that the air space was not essential to an enclosed fuse, and maintained the superiority of a solid-packed or solid-filled type. This position seems to have been correct, for, except in small capacities and for delicate fuses, the solid filled arrangement will probably become the standard enclosed fuse structure (see *Figs. 14, 15, 16, 17*).

In the following analysis of the principles and essential

elements of enclosed fuse devices, it is intended to show the desirable qualifications which devices of this character should possess, and not so much lay down all the necessary laws and formulæ for their production and manufacture. In view of the almost universal development and adoption

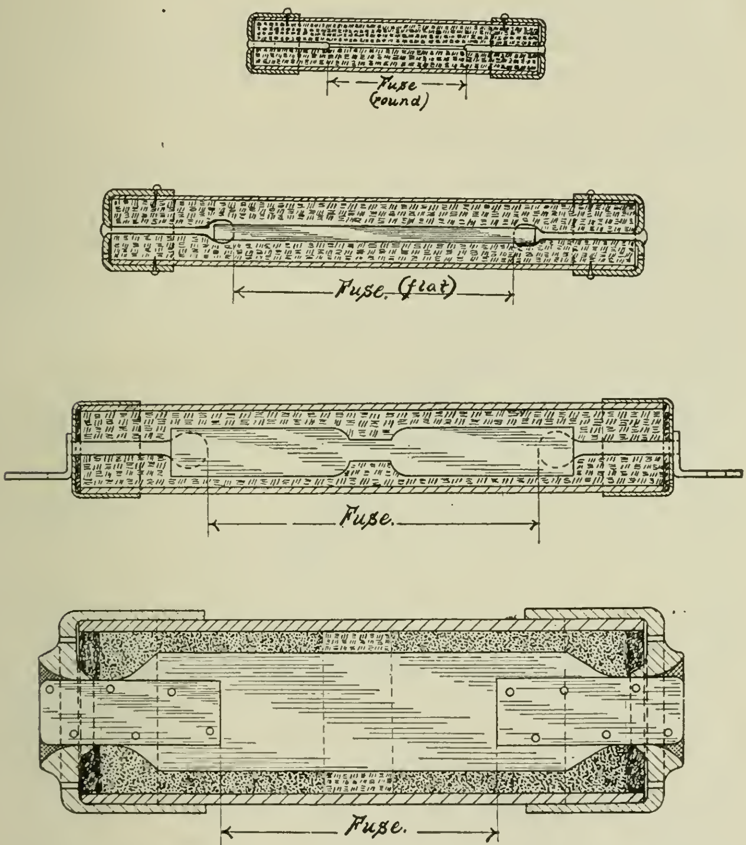


PLATE D, FIGS. 14, 15, 16, 17.—Sach's solid filled fuses (interior arrangement).

of enclosed fuse protective devices, a proper conception of the various principles which must be taken into consideration will be of interest to the users of such devices as well as to the manufacturer, to whom they are probably already known.

GENERAL PRINCIPLES AND EVOLUTION OF THE ESSENTIAL ELEMENTS OF ENCLOSED FUSES.

Two essentials require consideration: The heat-generating strip and the heat-dissipating environment, the latter including filling material, tube, terminals, etc. It is essential, therefore, that the thermal principles governing the operation of fuse conductors and the means necessary for the dissipation of the liberated heat energy during the normal condition and upon rupture of the fuse strip be carefully analyzed. The transformation of energy from watts to heat units is a simple interchange. The temperature attained, however, by the strip, and upon which its operation as a fuse conductor depends, is a result affected by a multitude of conditions. Environment and arrangement of the conductor, its radiating surface, specific heat and heat conductivity must assume fixed value before it is possible to obtain definite and accurate rating results. In exposed fuse wires these factors cannot be permanently fixed, but in addition to this difficulty there are others, such as the deteriorating effect of oxidation, difficulty of manipulation, ease of mechanical injury, etc. The absorption or elimination of the heat manifestations upon rupture of the fuse device on voltages sufficient to maintain arcs is perhaps even more essential than the fixing of the elements affecting accuracy of rating. Briefly stated, therefore, the function of an enclosed fuse is to provide a definite means for heat absorption and heat dissipation, which result must be accomplished without destroying or unduly deteriorating the external parts. Ideal adjustment of the various fuse-wire characteristics is practically impossible, owing to the lack of a commercially available metal possessing all the necessary qualifications. A careful consideration of the following characteristics of the metal selected as a fuse conductor is essential to obtain the best results.

So far as its carrying-capacity features under normal running conditions prior to rupture are concerned, the conductor should be of high electrical conductivity. The potential drop is thus reduced to a minimum, and the conse-

quent smaller section and mass require less energy to effect the temperature.

A low melting point is desirable, because the heat produced in the fuse strip is transmitted by conduction to all

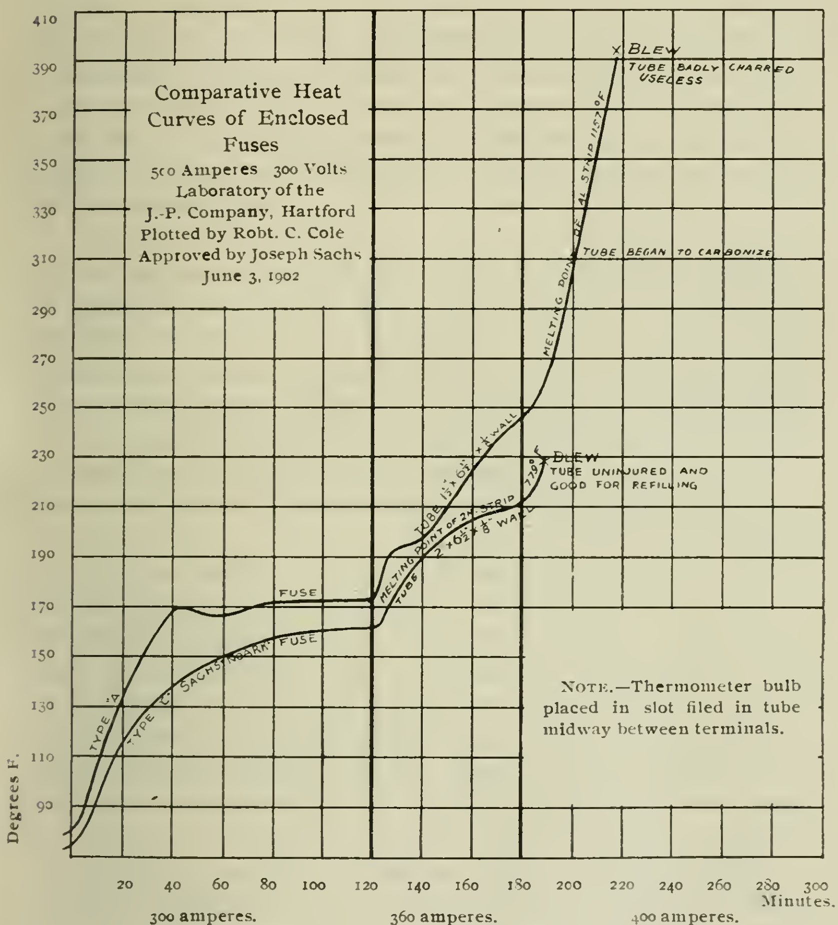


PLATE E, FIG. 18.—Relative heating of enclosed fuses.

connected parts, heating them correspondingly. For obvious reasons the operative temperature of the terminals holding contacts, tubular casing, etc., should be reduced to a minimum.

Most metals, if of good conductivity, are usually of high melting point. The fuse conductor should preferably have a melting temperature as much below red heat as is consistent with good conductivity. Conductors whose melting point exceeds 1000° F. are scarcely desirable if it is intended that they should normally operate at their maximum carrying capacity. This is a regrettable condition, because there are several metals which, considered from the standpoint of other essential features, act very well, but which produce deteriorating or destructive temperatures in the environment or connected parts. The behavior of relatively high and low melting-point fuse strips is illustrated by the curves in *Fig. 18*.

The specific heat of the metal affects various operative properties of the fuse strip. If it should be sensitive to load conditions, a low specific heat is essential. If some inertia in its operation is desired, the reverse is necessary. The behavior of the fuse is, however, more particularly governed by the heat capacity of its enviroment.

Constancy in the molecular structure of the metal which necessarily affects the resistance, melting point, etc., is of obvious importance.

Heat conduction through the strip to the external contacts should be minimized in order to obtain constancy of temperature. Most of the heat should be dissipated from the surface of the conductor to its environment. A conductor of small section with small terminal connections is desirable. In view of the considerations just enumerated the contacts, terminal wires, etc., from the fuse strip to the block contacts should be as small as is consistent with the necessary contact and electrical conductivity.

Under abnormal load conditions it is an advantage to have the time interval of operation decrease more rapidly than in a direct inverse ratio to the current. For this reason a fuse strip made of a metal having a large temperature co efficient will show the best results.

Under rupture conditions it is primarily essential that the strip should pass from normal to zero conductivity, with the minimum heat demonstration and arcing. Some

metals, when vaporized, have what might be called arc-sustaining properties, while others sustain the arc with difficulty. With the former the arc may be maintained to a much greater distance between the electrodes than with the latter. It would appear that the arc-sustaining properties of metallic vapors depend upon their electrical conductivity. Experiments demonstrate that metals whose vapors rapidly oxidize are poor arc sustainers, while those in which the metallic vapors retain their conducting character to a greater degree sustain the arc with great vehemence. Such metals as copper and its alloys are undesirable as fuse conductors, while aluminum, zinc, lead, cadmium and similar metals show a much better behavior under arcing conditions. The relative arcing properties can be very quickly demonstrated by subjecting the various conductors to be investigated to rupture under conditions of maximum carrying capacity and fixed overload. In this connection the behavior of the metal in passing from a molten to a vaporous condition may also be considered. A metal which changes gradually from one state to the other is preferable to one which changes its condition with explosive effect. The writer has used lead-tin alloy, aluminum, zinc, cadmium, tin, etc., but experience has demonstrated the superiority of metals of the zinc group in meeting the requirements.

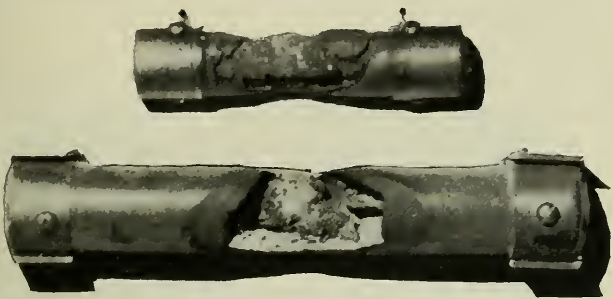
The maintenance of arc is also dependent upon the length of conducting strip used as a fuse. Every metal has a definite arcing distance, under certain fixed excess-current conditions, which depends upon its environment. It is a simple matter to have the strip's length amply exceed this distance. While it would, therefore, seem desirable to lengthen the strip, excessive length is impracticable, owing to size limitations in the complete device, and also because excessive length in the fuse strip results in correspondingly greater heat developed and a larger essential E.M.F. expended upon the terminals of the device. The writer has endeavored to obtain the desired result more through the medium of the filling than by the use of exceedingly long conductors. The size feature of enclosed

fuses has been one of the objections cited against them, where space is limited.

The mass of metal vaporized has an important bearing upon the satisfactory rupture operation of the fuse strip. With any definite tube section and length the arcing and explosive tendencies will primarily depend upon the temperature and volume of the confined heated vapor and air. In addition to the other considerations affecting the section and length of the conductor, maximum radiating surface is therefore desirable, owing to its effect upon the carrying capacity and essential size. It is also important that the conductor be in contact with the maximum amount of filling material in order to readily dissipate the heat of the expanding gases upon rupture. Several arrangements are possible: the subdivision of the fuse conductor into a number of separate strips connected in multiple between the terminals, but separated from one another so that each is entirely surrounded by the filling material, has been used (see *Fig. 13*). A simpler and more positive arrangement is used in the writer's fuses (*Figs. 14, 15, 16, 17*), consisting of a thin flat strip having the maximum contact with the surrounding mass consistent with mechanical strength. In connection with the desirability of reducing the metallic mass, it is regrettable that the necessity of limiting the melting temperature of the metal does not permit of obtaining the advantages in this direction resulting from the use of metals having a comparatively high melting point, and consequently larger carrying capacity for a certain section.

There are many insulating substances which from a casual inspection of the problem could apparently be utilized as a filling powder for surrounding the fuse wire. Investigation shows many of them to be lacking in the essential properties. The filling material should have even and unvarying thermal characteristics, and when placed in the fuse tube it should leave innumerable interstices between its particles. Coarse powders are best, as they provide the maximum contact with the gases, which thus part with their heat by conduction, combination or otherwise, and if not entirely dissipated in the filling, the remaining volume

readily passes to the exterior. It is a fallacy to assume that any combination of conductor and filling will be satisfactory. Ordinary lead-tin fuse wire could be surrounded by powdered chalk, retained by a suitable tube. Upon rupture, the disrupting tendency due to the expansion of the highly heated gases is checked and the arc broken up by the action mentioned. This combination is, however, defective, except on short circuit, where the disruption of the strip is absolutely assured, due to the tremendous heat energy suddenly impressed upon it. Under overload, it is deficient, because the oxide film supported by the filling material will hold the wire in a molten condition. The con-



FIGS. 19 and 19 A.—Sand-filled, 220 and 500 volts.

FIG. 20.—Chalk-filled, lead-tin wire.

PLATE F.—Sand and chalk-filled overload blown fuses.

tinuity of the highly heated conductor is maintained until mechanically disturbed, or the metal has been volatilized to the ultimate destruction of the tube.

RECORD OF TEST OF X SOLID-PACKED FUSE—GENERAL DESCRIPTION OF FUSE.

Grey fiber tube diameter ½ inch, length 2½ inches including brass ferrule caps at ends which served as contacts and to which tin-lead alloy fuse wire was directly soldered, extending from ferrule to ferrule centrally through a filling of white powder of chalky appearance and character. Fuse marked 6 and intended for 220 volt service. Not knowing what this rating was intended to imply, the fuse was started at 4 amperes and current increased.

4 Amperes for 5 minutes	Block in which fuse was support well shaken after each interval. Tube hot.
5 " " 5 "	
6 " " 20 "	
7 " " 15 "	At end of this time block given two quick raps and fuse opened. Tube abnormally hot.

With ordinary sand as a filling material the arc will probably be broken under short-circuit conditions. Such substances, however, conduct when melted. On overload, the molten filling in the small break space between the ends of the fuse wire will permit a current flux with sufficient resulting heat to finally detroy the complete structure. Fuse tubes filled with chalk and sand, blown on overload, are shown in *Figs. 19–20.*

In the enclosed fuse devices developed by the writer, a combination of the fused metal and the filling material is effected, but without any destructive action. Such combining action has advantages which will be noted later. Extensive experiment has been necessary to evolve a filling powder which would not maintain the continuity of the molten conductor or form destructive conducting combinations. To effect the first result an oxide dissolving or fluxing material is incorporated with the filling, and at melting temperature acts upon the oxide film surrounding the conductor in the same way that a quantity of borax thrown upon molten lead will clean off the oxide upon its surface. Recent developments indicate that non-hanging breaks can also be obtained by adjustments in the character of the metal employed, its section, radiating surface and the various heat properties of the surrounding filling, which can be made in the case of certain fuses. With the oxide fluxing filling, the rupture of the conductor is an absolute certainty irrespective of these considerations. (*Figs. 21, 22, 23* show ruptures of fuse strips surrounded with fluxing filling material).

A filling powder, to be properly operative, should possess certain thermal characteristics before and after rupture, and also possess excellent arc-killing properties. Greatly differing breaks can be obtained with a certain fuse strip, under

fixed conditions of rupture. The table (*Fig. 24*) shows the varying breaks obtained in a few of the materials tested.

Too much stress should not be laid upon a small break, as may be gathered from prior statements. A leak through the heated filling between the break-points after rupture may not be sufficient to cause a further melting of the conductor, and yet result disastrously, due to the extremely rapid temperature increase. Conductors, used in materials that show the slightest conducting tendency under heat

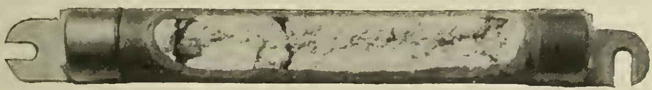


FIG. 21.—Short-circuit rupture of 500 volts, 50 amperes. Fuse showing combination.

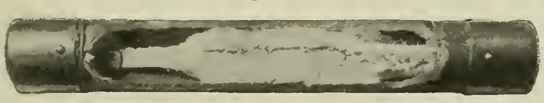


FIG. 22.—Solid packed 500 volts, 50 amperes. Ruptured by overload at normal voltage.

FIG. 23.—Solid packed fuse ruptured by overload at low arcless voltage. Note central location of rupture.

PLATE G.—Fluxing filling action on rupture.

action, must rupture with long breaks on overload. An enclosed fuse should therefore be tested under all conditions of service, both overload and short circuit; for while the enclosed fuse structure may operate satisfactorily upon short circuit, with its instantaneous, long rupture, the same strip in the same filling may operate very disastrously under the much smaller disruptive strain of a small overload. The break should be absolute to insure safe operation.

As much as possible of the liberated heat energy should be absorbed by the filling. The heat capacity of the filling is an important consideration in this connection. The use of a combining filling essentially absorbs some of the liber-

PLATE H.—ARC-RESISTING PROPERTIES OF FILLINGS.

Material.	Test.	Time.	Separation.	Material.	Test.	Time.	Separation.
		seconds.	inches			seconds.	inches
No. 2 Filling	1	15	7/8	Pulverized Alum	1	20	2 1/8
"	2	10	7/8	"	2	16	3/4
"	3	11	1 1/8	"	3	18	3/4
Slaked Lime	1	18	7/8	Fine S. S.	1	17	11/16
"	2	6	1 1/2	"	2	16	5/8
"	3	8	7/8	"	3	16	9/16
Gypsum	1	20	1 3/8	A. Silex	1	14	13/16
"	2	8	[illegible]	"	2	13	1 3/8
"	3	10	1 3/16	"	3	14	1 3/4
Chalk	1	12	1 5/16	No. 13 Filling	1	22	1 5/16
"	2	8	1 3/16	"	2	10	1 3/4
"	3	9	1 1/4	Portland	1	10	1 7/16
Competing	1	7	15/16	Cement	2	12	1 1/2
Filling	2	7	1 1/16	No. 3 Filling	1	8	9/16
"	3	9	1	"	2	10	1
Heavy Magnesia	1	9	1 1/8	"	3	11	1 7/16
"	2	10	1 1/4	No. 14 Filling	1	6	1
"	3	10	1 3/16	"	2	10	1
No. 15 Filling	1	10	1 1/16	"	3	9	1/8
"	2	10	1	No 5 Filling	3	10	13/16
Mica	1	6	1 3/4	No. 6 Filling	1	8	3/4
"	2	7	1 5/8	"	2	10	7/8
No. 5 Filling	1	12	7/8	"	3	10	7/8
"	2	12	11/16				

Fuse strip ZN ·018 x ·170 x 3 inches.
Fiber tube, 3/4 inch diameter, 5 5/8 inches long.
Overload current 50 amperes, 220 volts inductive load.
Clamp block opened and break measured after each rupture. J. P. Co. Lab., 10-8-20.

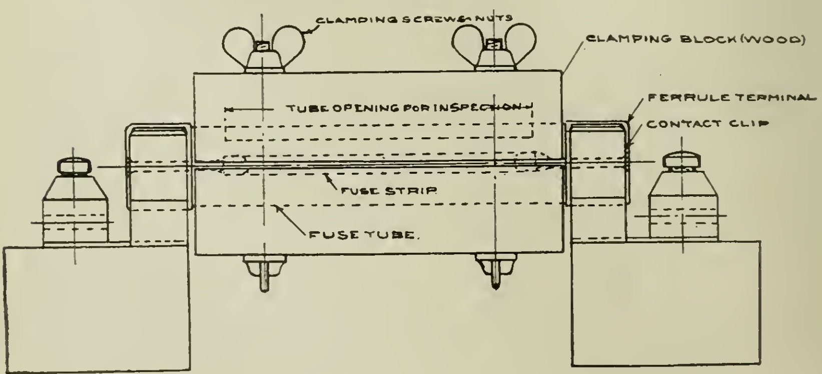


PLATE H.—FIG. 24.—Table of arcing distances and testing apparatus.

ated heat energy. The writer has demonstrated that fuses based upon a proper adjustment of these properties show a reduced external gas demonstration upon rupture. The break with a combining effect is also less abrupt than where the heat energy is dissipated by conduction alone.

For obvious reasons, the temperature attained by the complete structure must be minimized, and the effect of the thermal properties of the filling material on the time-interval of operation under overload conditions should be investigated. The heat capacity and total mass affects the time-interval of operation prior to rupture. Reduction in the total amount of filling material detracts from the rupture operation. With ample surrounding filling, the heated vapors resulting from any excess-current condition can be dissipated. The amount of heat-absorbing filling material and the consequent size of the retaining tube are governed by both the carrying capacity and voltage of the enclosed fuse strip. While the section and length of tube and enclosed mass of filling material around the fuse strip directly control its active operation on rupture, commercial considerations somewhat limit the size of the complete device. The table following gives some general tube and fuse-strip dimensions.

Some consideration must also be given to the disposition of the fuse strips relative to the tubular casing. Since the rupture should be entirely surrounded by the filling material, the fuse strip is preferably connected between terminal wires of better conductivity extending from the tube-closing ferrules into the filling. Vented ferrules are necessary on large fuses.

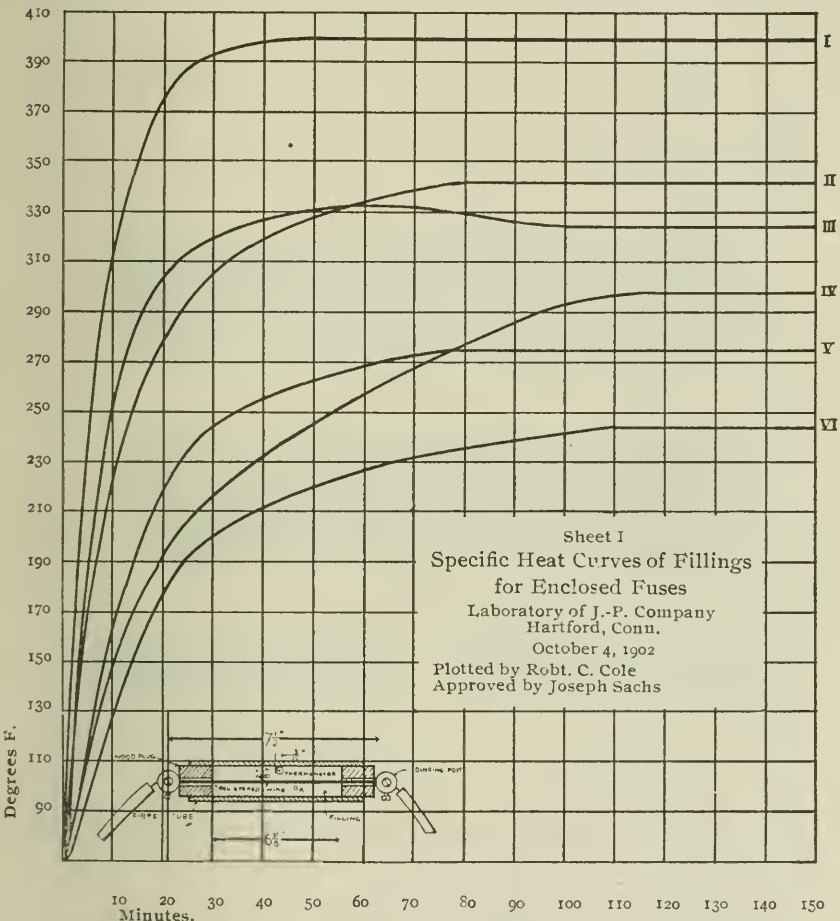
Fig. 25 shows some curves of heat capacity and behavior of substances available for fuse fillings. The filling material under test was held around a small electrically heated conductor by a fiber tube, and the temperature of the filling just inside of the tube taken at intervals until an even temperature had been reached. Materials showing a large specific heat capacity and a low maximum temperature will increase the carrying capacity of a certain fuse conductor, but decrease its sensitiveness to current changes with

PLATE Q.—LENGTH AND DIAMETER OF TUBES AND LENGTH OF STRIPS. "SACHS'" FUSES.

(Given tube length is over ferrules).

Volts.	Class Amps.	Tube Length.	Tube Dia.	Fuse Length.	Volts.	Class Amps.	Tube Length.	Tube Dia.	Fuse Length.	Volts.	Class Amps.	Tube Length.	Tube Dia.	Fuse Length.
		inches.	inches.	inches.			inches.	inches.	inches.			inches.	inches.	inches.
	1-8	$2\frac{3}{16}$	$\frac{3}{8}$	$1\frac{1}{4}$		1-10	$4\frac{5}{8}$	$\frac{3}{8}$	3		1-12	$5\frac{3}{4}$	$\frac{1}{2}$	$4\frac{1}{2}$
	10-15	$2\frac{11}{16}$	$\frac{3}{8}$	$1\frac{1}{4}$		12-25	$5\frac{1}{4}$	$\frac{1}{2}$	3		15-30	$5\frac{3}{4}$	$\frac{5}{8}$	$4\frac{1}{2}$
	20-30	$3\frac{3}{16}$	$\frac{1}{2}$	$1\frac{1}{2}$		30-50	$5\frac{3}{4}$	$\frac{3}{4}$	3	2,500	35-50	$6\frac{1}{4}$	$\frac{7}{8}$	5
	35-50	$3\frac{3}{4}$	$\frac{3}{4}$	$1\frac{3}{4}$		60-100	$6\frac{1}{4}$	1	$3\frac{1}{2}$		60-75	$6\frac{15}{16}$	$1\frac{1}{8}$	$5\frac{1}{2}$
220	60-100	$4\frac{1}{8}$	$\frac{7}{8}$	2	500	125-150	$6\frac{1}{4}$	$1\frac{1}{4}$	4		80-100	$6\frac{15}{16}$	$1\frac{1}{4}$	$5\frac{1}{2}$
	125-150	$4\frac{1}{8}$	1	$2\frac{1}{2}$		175-225	$6\frac{7}{16}$	$1\frac{1}{2}$	4					
	175-225	$4\frac{11}{16}$	$1\frac{1}{4}$	$2\frac{1}{2}$		250-400	$6\frac{5}{8}$	2	4					
	250-400	$4\frac{13}{16}$	$1\frac{1}{2}$	$2\frac{1}{2}$		500-600	10	$2\frac{1}{2}$	4					
	500-600	$6\frac{3}{16}$	2	$2\frac{1}{2}$										
	$\frac{1}{2}$-12	$15\frac{1}{8}$	$\frac{3}{4}$	13	10,000	$\frac{1}{2}$-12	24	$\frac{3}{4}$	18	20,000	$\frac{1}{4}$-10	30	1	24
5,000	15-30	$15\frac{1}{8}$	1	13		15-30	24	1	18					
	35-50	$18\frac{1}{8}$	$1\frac{1}{8}$	14										

resulting slow overload operation. Increased carrying capacity, however, results in a larger heat output from the conductor with increased temperature in the entire fuse structure, at the maximum continuous load. Materials of



I. Carbonate of Magnesium.
II. "H" Silex.
III. "100" Mica.
IV. Crayon Chalk.
V. Asbestic.
VI. Fine Soapstone.

PLATE I, FIG. 25.—Heat capacity curves.

low specific heat minimize the carrying capacity of the conductor, due to the fact that the heat units absorbed in raising the temperature are comparatively small. Enclosed fuses, in which fillings of this nature are used, operate at

a lower temperature and show a smaller time-interval in adjusting themselves to load changes. The heat capacity of the filling also affects the rupture operation. Maximum heat should be absorbed in raising the temperature. An enclosed fuse filling should not be extreme in either direction, but rather strike a happy medium.

In addition to the general elements discussed, the writer's fuse structures embody several other features, which have proven of practical service value. If an enclosed fuse is properly operative, there will be no exterior manifestation of its interior condition. It is absolutely essential, therefore, that means be provided to at all times indicate the condition of the fuse conductor. The writer's earliest commercial developments embody an external indicator and he has devised a variety of methods for this purpose. A simple means for obtaining indication is by the use of a small, high resistance wire, connected in shunt with the main fuse. This indicating wire may be placed entirely upon the exterior surface of the tube and left exposed to view, or it may be covered by a paster throughout its entire length; but it is preferably placed almost entirely within the tube structure with a small portion brought to the surface through suitable holes in the tube. This indicating portion is covered by a label, underneath which, and in contact with the indicator wire, is a spot of material affected by the heating and destruction of the indicator wire, and discolors the label. Inspection, therefore, at once indicates the condition of the interior structure. The indicating wire, if of correct resistance, normally carries no current and does not open until the conductivity of the main conductor has been lowered sufficiently to allow a rupturing current to pass through it.

A shunted high resistance wire also indicates the character of the interior disruption. The disrupting manifestation of an indicator wire entirely exposed on the surface of a tube containing an interior main-fuse fire is very slight. The same wire, without any interior main-fuse conductor, opens with comparatively severe disruptive effect. This action is due to the gradual break in the main-fuse wire.

In passing from its maximum to zero conductivity it is at some particular instant equal in resistance to the indicator. Disruption of the indicator follows, but the final break takes place in the interior conductor. *Figs. 26, 27, 28, 29* show this action and also the "spot" indicator before and after blowing.

The prevention of an indiscriminate interchange of fuses in their receiving blocks is an advantage readily obtained with the enclosed fuse. Adjustment of the various lengths and diameters, which are essential in fuses for different

FIG. 26.—Exposed indicator with interior fuse.

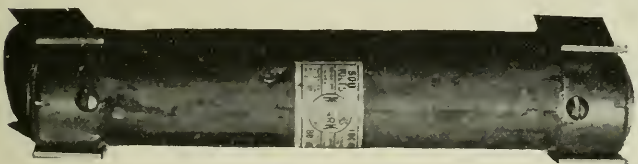


FIG. 27.—Exposed indicator without interior fuse.

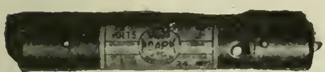


FIG. 28.—Sachs' spot indicator unblown.

FIG. 29.—Sachs' spot indicator blown.

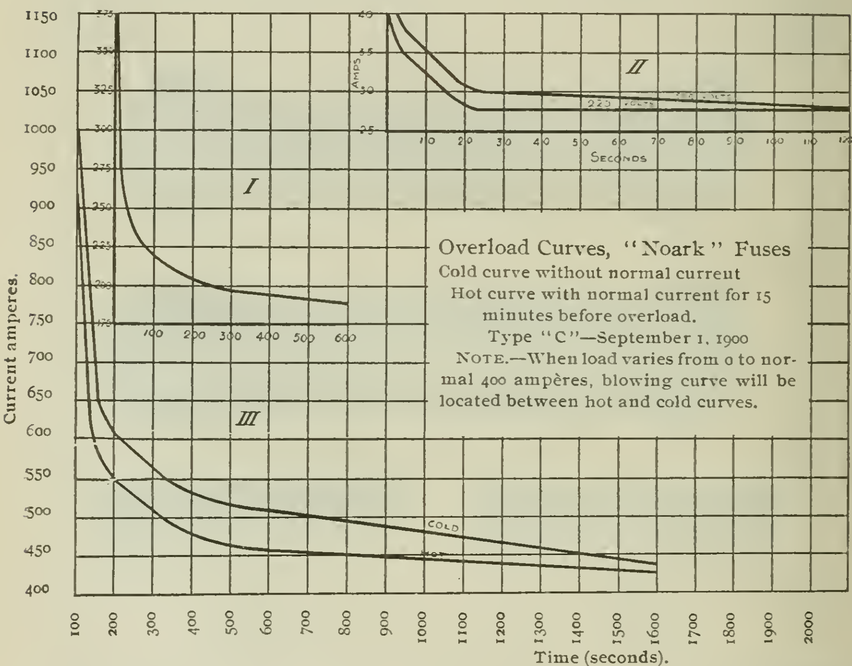
PLATE J.—Exposed and "spot" indicator action.

voltages and ampere capacities, make it very simple to so dispose the fittings and contacts that fuses of larger capacity cannot be inserted in smaller capacity blocks.

A great deal of discussion as to the rating of fuse-protective devices has been indulged in within recent years, and it is regrettable to note that the National Electric Code embodies amongst its enclosed fuse requirements a rating clause as follows:

"Must be rated at 80 per cent. of the maximum current which they will carry indefinitely," etc.

The writer has always maintained the incorrectness of this system of rating. In his opinion, a protective device should be rated on the same basis as the apparatus which it protects; that is, at its maximum capacity for continuous service. In order, however, to comply with the above-mentioned requirements, both the maximum carrying capacity and the code rating (80 per cent.) are placed upon the fuse.



I. 500 volts 150 amps., hot curve. II. 25 amps., hot curve. III. 500 volts, 400 amps.

PLATE K, FIG. 30.—Overload time curves.

All of the writer's fuses embody very much the same structural elements in the way of fiber tubes, filling, fuse wire, terminal wire, and a variety of contact arrangements. In the development of the latter it has been the aim to provide screw-driverless contact fittings, so that the manipulation of the fuse device does not require the use of tools, even for the larger current capacity. The service requirements at the several commercial voltages have been care-

fully studied. Some of the different forms of blocks, fittings, contacts, etc., are illustrated.

THE OPERATION AND APPLICATION OF ENCLOSED FUSE DEVICES.

The enclosed safety fuse is essentially a time-interval protective device. The fuse environment serves as a heat reservoir, whose properties give to the device the much desired time-interval function. At the same time, however, it will resist or insulate a heat input beyond its capacity, which feature, taken in conjunction with the increase in resistance as the temperature of the wire rises, produces very rapid decrease in the time-interval under extreme conditions. The overload curves, *Figs. 30–31*, show these characteristics. In standard fuses, overload time-intervals as follows have been adopted. These may appear somewhat small for certain purposes, but it was found necessary to meet the average requirements.

220 volt	fuses to and including 15 amp.	blow at 25 p.c. overload	in	15–30 sec.
" "	" from 20–150 amperes	" " " "	"	" 30–60 "
" "	" " 175 " up	" " " "	"	" 100–300 "
500 "	" to and including 25 amp.	" " " "	"	" 15–30 "
" "	" from 30–150 amperes	" " " "	"	" 60–100 "
" "	" " 175 amperes up	" " " "	"	" 100–300 "
2500 "	" to and including 12 amp.	" " " "	"	" 15–30 "
" "	" from 15–100 amperes	" " " "	"	" 30–60 "

These time-intervals are for fuses that have been in circuit for some time and with a temperature of 75° F. in the surrounding atmosphere.

Every effort is made to reduce the factor of error in manufacture. About 5 per cent. allowance each way in the maximum carrying capacity of such devices is not beyond reasonable limits, and a slight variation of the overload time-intervals is also to be expected.

The continued integrity of a fuse wire surrounded by substances of the character used in filling materials, and particularly those containing fluxing mediums, has been questioned. A multitude of the writer's fuses in service have not yet demonstrated that there is any such action. It is, however, obvious that if at any time the wire reaches its melting temperature the condition of the fuse-strip is

affected, even though the abnormal condition ceases before rupture occurs. The fluxing medium, or other component parts of such fillings, show no deteriorating action until the melting temperature has been reached and continued for a sufficient time.

It is obvious that a structure embodying the heat properties inherent in an enclosed fuse will have a somewhat different time-interval of operation when first put into service than it possesses after operating for some time at normal current conditions. The ratio of these relative time-intervals is less than would be expected, although it increases with the size and capacity of the fuse, as is shown by the following test-record.

HOT AND COLD OVERLOAD TIME—SOLID PACKED FUSES.

Rating.	Carried.	Time.	Overload.	Opened.	Ratio Hot to Cold.
500 volts, 40 amperes, flat single fuse.	40 a	1 hr.	50 a 50 a	55 sec. 210 sec.	11 to 42
500 volts, 25 amperes, flat single fuse.	25 a	1 hr.	30 a 30 a	45 sec. 195 sec.	3 to 13
2,500 volts, 50 amperes, flat single fuse.	50 a	1 hr.	62½ a 62½ a	30 sec. 120 sec.	1 to 4
220 volts, 10 amperes, round single fuse.	10 a	1 hr.	12 a 12 a	10 sec. 30 sec.	1 to 3

To demonstrate the rapidity of action of the enclosed fuse strip, a very simple test is made by connecting an enclosed and exposed fuse strip in series, both strips being of the same metal and identical in section and length. The record of such a test given here shows by the less vehement disruption of the exposed strip, when disrupted in series with the enclosed strip, that the latter operated first, breaking the arc.

COMPARATIVE 500-VOLT SHORT-CIRCUIT TEST OF FLAT STRIPS IN SOLID-PACKED CASE AND AIR EXPOSED.

Open and enclosed fuses, rated 40 A. 500 V. enclosed. Flat strip ·018 × ·13 × 3 inches between copper terminal wires ·11 diameter, 6¾ inches between center of contact posts.

Exposed Fuse Strip Alone.—Very severe arcing and burning of terminal wire back to posts. Break 6 inches.

Exposed Fuse Strip in Series with Enclosed Strip.—Both fuses opened but exposed strip simply disrupted in terminal wires without any burning and only slight snap. Break 3 inches in each exposed fuse.

Varying conditions of abnormal current result in correspondingly severe shocks to the enclosed fuse structure. The disruptive strain upon the protective device varies with its location, the capacity of the generating apparatus, the

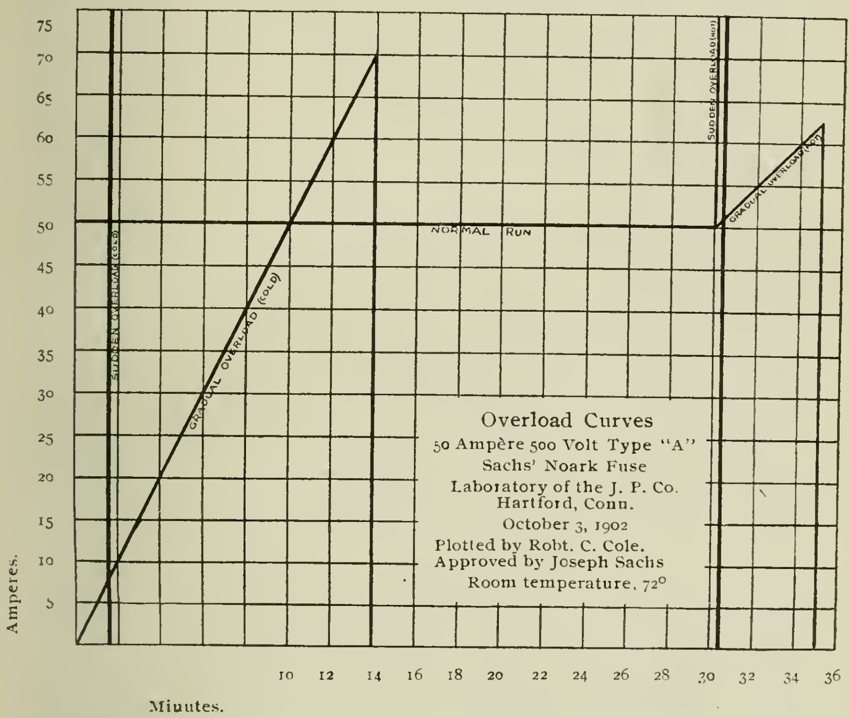


Plate L, Fig. 31.—Overload time curves (gradual and sudden overload).

amount of load other than that imposed upon the fuse device, the power factor of the system protected and the ability of the current source to maintain the working voltage. Where abnormal current suddenly demanded from the current-supplying apparatus causes a momentary reduction in the working potential, the stress imposed upon the protective device at the moment of rupture is very much less than if the E.M.F. and current are maintained. With

over-compounded generating apparatus, small armature reaction or low-power factor, short circuits are of maximum severity. While enclosed fuse devices can be constructed to meet the most severe condition under any service, practical commercial limitations prohibit free sway. The writer has always maintained that a protective device need only accomplish satisfactory results under the particular conditions of service for which it is intended. It would scarcely seem necessary, for instance, that an enclosed fuse intended for street railway-car service need be designed to withstand the abnormal stresses imposed upon it if operated under short-circuit conditions at a minimum distance from generating apparatus of several thousand kilowatts.

Similar considerations are also pertinent in considering the use of enclosed fuse devices for service on different voltages and character of current supply. In rating enclosed fuses at certain voltages, average conditions of service should be considered in the adjustment and size of the component parts more than exceptional conditions.

Enclosed fuse devices have found successful application in almost every electrical service. Their inherent advantages, and particularly the freedom from fire-risks, have resulted in their adoption as the standard protective device for all interior construction where the voltage is in any way sufficient to result in disastrous disruption and damage. The various Inspection Bureaus throughout this country have adopted rules permitting the installation and use of such devices without the many restrictions required where air-exposed fuses are installed. Minimizing of careless and indifferent fusing, in cases where this is done by inexperienced persons and easy manipulation, is another advantage universally recognized.

As a motor-protective device the enclosed fuse may well be said to be ideal, since it possesses all of the operative elements essential for correct motor protection. The time-interval function in such applications is undoubtedly essential. On the electric railway service, enclosed fuse devices have been used very extensively for the protection of the car motors. As an instance, it may be stated that there are

over six thousand surface trolley cars protected with enclosed fuse equipments, and they have also been adopted for the protection of the motor equipment of nearly all of the large elevated railways. Railway managers seem to have found that time-interval operation, accuracy and safety obtained by the use of such devices have minimized repairs accounts

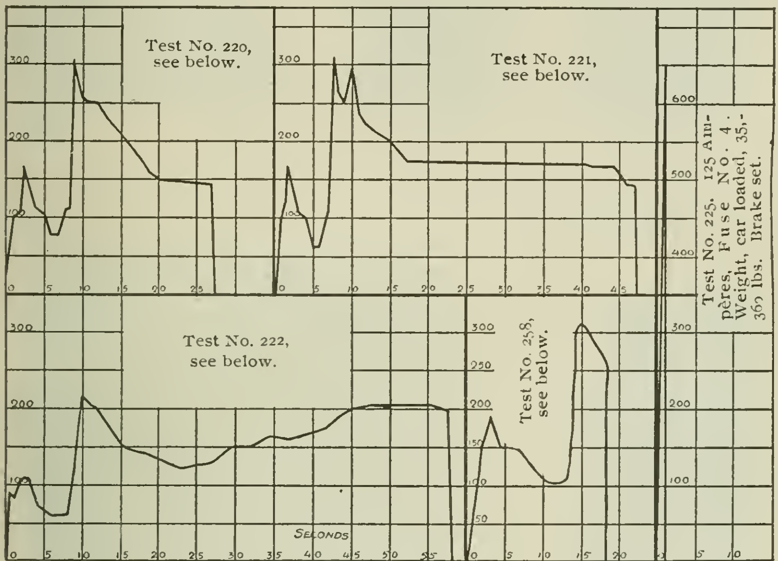


PLATE M, FIG. 32.—Car operation curves.

Test No. 220, 125 Ampère, Fuse No. 2. Weight, car loaded, 25 360 lbs. Ascending grade, 2 per ct. Distance run by car, 404 feet. Fuse held. Curve shows current input during this time.

Test No. 221. 125 Ampères, Fuse No. 2. Weight, car loaded, 35,-360 lbs. Ascending grade, 4·63 per ct. Distance run by car, 816 ft. Fuse held. Curve shows current input during this time.

Test No. 222. 125 Ampères, Fuse No. 2. Weight, car loaded, 35,-360 lbs. Ascending grade, 5·17 per ct. Distance run by car, 799 ft. Time to fuse blowing, 58½ sec. Curve shows current input during this time.

Test No. 258. Fuse, 100 Ampères. Fuse opened at 315A. Fuse No. 1.

and damage suits. Actual tests of car-service operation of enclosed fuses demonstrates their peculiar fitness for the purpose. The curves, *Fig. 32*, show actual tests made by the engineers of a large street railway system and indicate the peculiar operative features under such service. Comparative tests made with electro-magnetic circuit breakers and enclosed fuses show a marked difference when the

motion of the car is brought to a stop by the opening of the protective device. In the case of the circuit-breaker operation the cessation of motion is of a jerky nature, whereas, with the enclosed fuse, the slowing down is very gradual and is not noticeable by any disagreeable effect of the character mentioned. The undesirable result in the case of the instantaneous rupture of the circuit breaker is probably due to the inductive potential increase with the sudden resulting acceleration in the motor armature. The following test-record illustrates this feature and other peculiar advantages.

500 VOLTS SACHS' FUSE TESTS, 150 AMPERES, CAR NO. 635.

No. 2.—Half-way House to Pines River Bridge. Readings Five Seconds Apart.

Amperes.	Amperes.
245	205 Brake set.
305X	205 Brake set.
225	245 Brake set.
155	245 Brake set.
135	245 Brake set.
125	235 Brake set.
165 Brake set.	235 Brake set.
205 Brake set.	245 Fuse blown, car stopped without a jerk.
230 Brake set.	

RUN CONTINUED WITH NEW FUSE.

Car off track at Revere Street.

Circuit breaker out five times. (Had to be held in to get car in position again.)

Fuse did not blow.

No. 6, 150-ampere fuse blown, throwing overhead switch on short circuit.

No. 7, 60-ampere fuse blown, throwing overhead switch on short circuit.

The unalterable fixing of the motor behavior due to the limitations imposed upon it by the protective device make it possible to check the behavior of motor equipments in actual service and thus by timely repairs minimize the maintenance account. The relative merits of enclosed fuses and other devices for motor-car equipment protection scarcely require discussion. The fact remains that comparative tests under actual service conditions certainly indicate the advantages of the enclosed fuse. The advantages resulting from the use of the enclosed fuse in railway

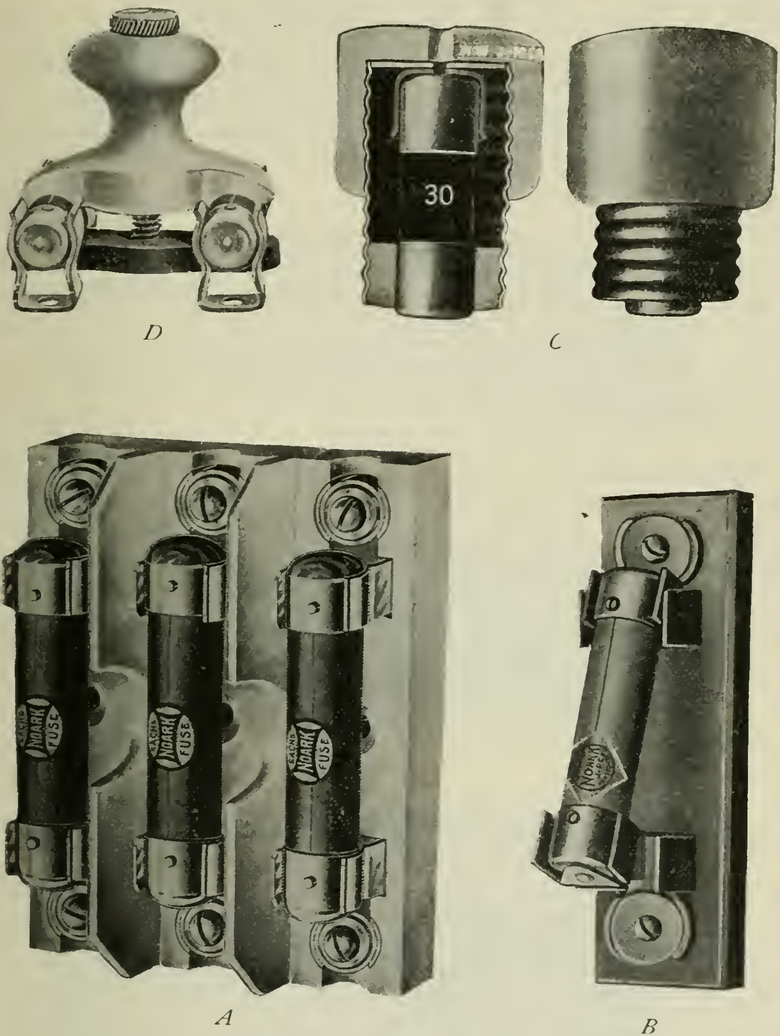


PLATE X.—220-volt Sachs' enclosed fuse devices.

A, three-pole 20–30 amperes main line block type "B." *B*, single-pole 60–100 amperes main line block type "C." *C*, enclosed fuse plug for Edison cutouts (interchangeable fuses). *D*, switch and fuse combination for panel boards.

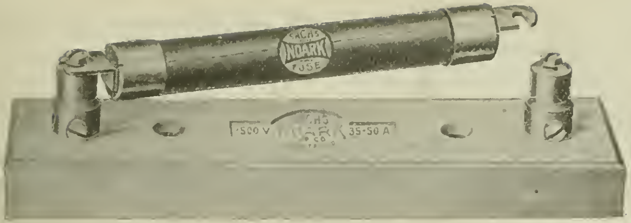
service are also apparent under most other conditions of motor service.

The value of non-arcing protective devices on potentials of 1,000 volts and above cannot be over-estimated. Innumerable arrangements have been utilized to minimize the arc resulting from rupture, many of which are very satisfactory, although complicated and expensive. The enclosed fuse has found a most prolific field in this direction. While it has already been developed for a multitude of services at these higher potentials up to, say 2,500 volts, great possibilities are to be expected from future developments and improvements. As a line cutout on alternating systems the enclosed fuse is being very extensively used, to the displacement of other devices. In the very high transmission system potentials, reaching up to 20,000 volts, some very satisfactory results have been forthcoming. The serious disadvantage, however, in the enclosed fuse for this purpose is the necessity for exceedingly great length, which objection, however, the writer hopes to overcome in the near future.

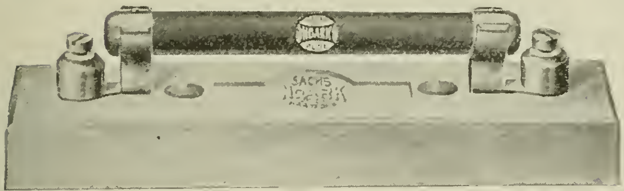
Safe and accurate fuses can now be obtained for standard electrical service, in capacities as follows:

220 volts up to	1,000	amperes,	D.C.
500 " " "	600	"	"
1,500 " " "	200	"	A.C.
2,500 " " "	100	"	"
5,000 " " "	50	"	"
10,000 " " "	30	"	"
20,000 " " "	10	"	"

Higher voltage fuses have also been constructed and tested, but no standard device has been developed as yet. Single fuses, which normally control nearly 400 kilowatts of electrical energy at 600 volts, and which rupture under short-circuit conditions on current values reaching thousands of amperes, are in daily successful operation. In several cases single fuses have been connected in multiple with an aggregate capacity of three or four times the above. On 2,500 volts A.C. successful opening of short circuits at the bus bars of about 1,000 kilowatts of generating apparatus with



E



F

G

H

PLATE O.—500 and 2,500 volt single-pole Sachs' enclosed fuse devices.
E, 2,500 volt, 50 amperes, type "A" cutout. *F*, 500 volt, 25 amperes, type "B" cutout. *G*, 2,500 volt, 100 amperes, type "D" cutout. *H*, type "C" 500 volt, 600 amperes, heavy traction cutout.

a holding voltage has been successfully accomplished with scarcely any exterior gas manifestation, the normal fuse rating being 100 amperes.

Multiple or series arrangement of enclosed fuses is not recommended. Where two or more fuses are used serially, they must all open simultaneously. The entire rupture effect will otherwise be imposed upon the fuse which opens first, resulting in its probable destruction. Practical manufacturing conditions prevent absolute duplication of the various physical characteristics in a device of this type. Absolutely uniform conductivity in each of the parallel fuses is, therefore, as impossible as absolutely simultaneous action in the series-connected fuses. Unless ample allowance is made for the uneven division of the current, a multiple combination will blow when unnecessary. The use of enclosed fuses on voltages below that for which they are rated is productive of excellent results and is frequently done. There are occasions where the standard fuse for any particular voltage does not give a sufficient factor of safety in its operation, and increased size, intended for the same ampere capacity at a higher voltage, is desirable. It may be noted that ruptures under certain 2,500-volt A.C. conditions are less severe than bad conditions at 500 D.C. The voltage rating should be considered more as a designation indicating the energy-rupturing ability of the fuse. It has been found desirable to increase both the length and diameter of the tube for a certain ampere rating as the voltage increases, and also as the ampere capacity increases with a certain voltage.

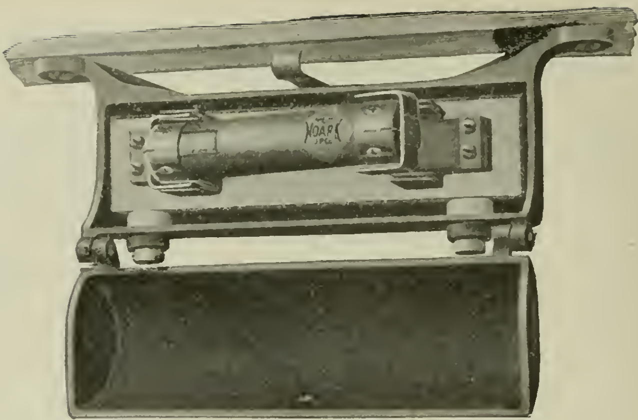
Comparatively higher first cost is probably the only reason why enclosed fuses have not already entirely displaced the open fuse wire or link. After the first expenditure, the use of an enclosed fuse structure is relatively cheap. Well-constructed enclosed fuses can be refilled and used repeatedly. As an instance of the possibilities in this direction, the following record of a refilling test is given:

TEST NO. 1 (REFILLING) 500 VOLTS, 150 AMPERES, STANDARD "D" SACHS' FUSE, ROOM TEMPERATURE 70° F.

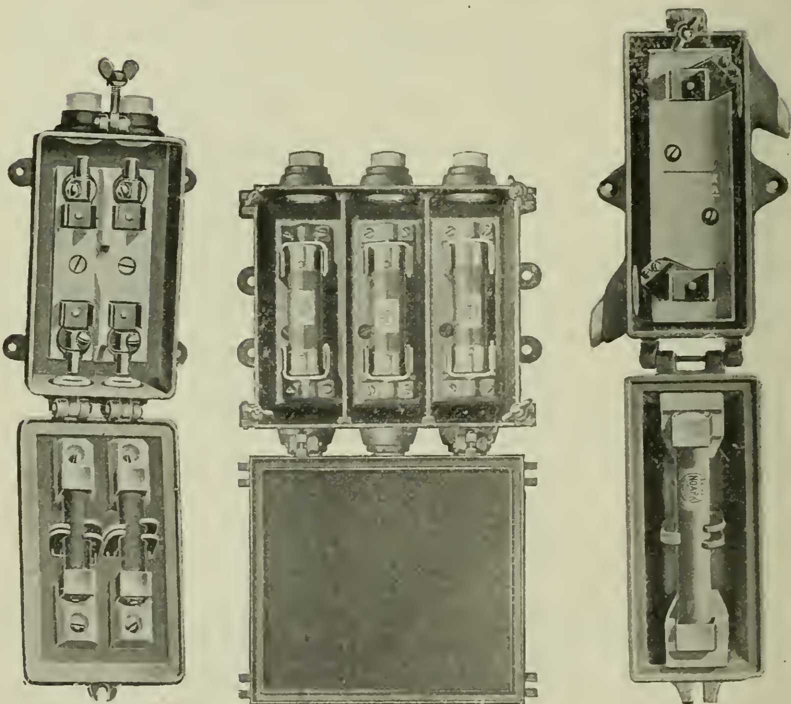
Same tube blown and refilled. Tube good for further use at end of Test 25.

Run No.	Date.	Voltage.	Time.	Current.	Remarks.
1	12 27 '01	500	Instantly.	S.C.	O.K., no gas.
2	"	500	"	"	" slight gas.
3	"	500	"	"	" "
4	"	500	"	"	" gas.
5	"	500	"	"	" no gas.
6	12 28 '01	500	"	"	" "
7	"	500	"	"	" "
8	"	500	"	"	" "
9	"	{300, 500}	Unknown.	375 Amperes.	" "
10	"	500	Instantly.	S.C.	" "
11	"	{350, 500}	63″	250 Amperes.	" "
12	"	500	Instantly.	S.C.	" "
13	"	{375, 500}	360″	200 Amperes.	" "
14	12 29 '01	520	Instantly.	S.C.	" gas.
15	"	{300, 325}	6″	400 Amperes.	" no gas.
16	"	520	Instantly.	S.C.	" gas.
17	"	{325, 500}	16″	320 Amperes.	" no gas.
18	"	500	Instantly.	S.C.	" "
19	"	{300, 500}	9″	405 Amperes.	" "
20	"	{250, 400}	21″	310 Amperes.	" "
21	"	{300, 500}	13″	335 Amperes.	" "
22	"	500	Instantly.	S.C.	" slight gas.
23	"	{300, 475}	22″	310 Amperes.	" no gas.
24	"	{300, 475}	33″	290 Amperes.	" "
25	"	510	Instantly.	S.C.	" "

Large current capacity enclosed fuses develop material heat when operating at the maximum continuous load, and the resulting temperature has been objected to. With a certain commercially salable tube size the temperature effect becomes a forced evil if the fuse has a satisfactory rupture operation. Lower temperature, under such condition, usually implies more metal in the the conductor. Excessive tube size, for obvious reasons, is impracticable.



I



J *K* *L*

Plate P.—Sachs' enclosed fuse and service boxes.

I, 500-volt car equipment. *J*, 220-volt service box acting as fuse and switch. *K*, three-pole, 220 volt, 225 amperes fuse box. *L*, single-pole, 2,500-volt transformer service cutout box.

Such temperature effects must, therefore, be looked at in the light of a necessary evil for the present. Improvement in this feature, consistent with satisfactory size and rupture, is a development of the near future. That heat and resulting increase in temperature are necessary accompaniments of thermal-protective devices should always be remembered by the user.

In conclusion, the writer believes that enclosed fuse-protective devices, if properly designed, can be constructed to operate accurately and safely at almost any abnormal condition. While many features require further development, and excessive size and cost may present obstacles in instances of particularly severe rupture effect, ultimate results will, no doubt, prove enclosed fuses the standard for all service.

NEW METHOD OF ARMOR-PLATE MAKING.

A new process of supercarbonization, or "face-hardening" of armor-plate, has been developed by an officer in the American Navy which promises to exert a greater influence upon the struggle for supremacy between guns and armor than was produced either by the American Harvey or the German Krupp processes before it. The method of increasing the resistance of homogeneous armor-plate by hardening its face may be said to have originated in this country when Harvey introduced his process of increasing the hardness by causing the surface of the plate to take up an excess of carbon during treatment in the furnace. Armor with a hard face upon a tough back had, it is true, been already produced abroad, the compound armor, which so many of the old English battleships carry, being of this character. But compound armor had the serious defect that the hard face consisted of a separate plate of steel welded upon a backing of softer and tougher metal. The hard face was secured at the expense of homogeneity, and the serious nature of this defect was realized at the proving grounds when the surface flaked and broke away from the softer back, leaving the plate open to penetration by shells of small caliber. The incontestable superiority of the Harvey armor led to its all but universal adoption throughout the world. Krupp eventually improved upon it, substituting gas treatment in place of the layer of carbonaceous material used in the Harvey method, and also improving the quality of the plate by very careful attention to the details of the furnace treatment. While the high quality of Krupp plate is unquestionable, its excellence is gained at enormous cost as high as $550 per ton having been paid for this class of armor.

The invention of Lieut. Cleland Davis, of the Navy, marks, both in effectiveness and in cost of manufacture, a great advance upon the Krupp system. His method includes the substitution of electrical currents for the heat of the gas-fired furnace, and the direction of these currents against the face of the

armor-plate while it is in a heated condition by means of massive carbon anodes, in form not unlike the carbons used in arc lights, but of vastly greater size. During his course of experiments, Lieutenant Davis found that if a current of electricity were sent from a carbon into the surface of a plate, it carried with it a certain amount of the carbon and implanted it within the body of the metal. The depth of the hardening is determined by the period of time during which the current is applied, and it is claimed that not only is the surface thus treated harder than that treated by the Krupp process, but the depth to which the hardening is carried is increased. The economy of the process may be judged from the statement that while the Krupp plate is kept in the soaking pits at a heat for from fifteen to twenty days, the same amount of impregnation with carbon is obtained with the Davis process in five hours.

The experimental plate was made at the works of the Bethlehem Steel Company. A moderate thickness, 5 inches, was chosen, and the only complaint made against the quality of plate was that the hardening of the face was not uniform, a fault which is attributed by the inventors and makers entirely to the experimental nature of the electrical appliances employed and not to any inherent defect in the process. In the next plate that is fabricated, carbon rollers are to be substituted for the present anodes, and with these it is expected that a uniform depth and hardness of carbonizing will be secured. It is estimated by Lieutenant Davis that, as compared with Krupp plate of equal resistance, the new system will produce plates from 20 to 30 per cent. lighter in weight. Further developments of this process will be watched with the greatest interest, and should it prove possible to secure these remarkable results on a commercial scale, the effect upon warship construction will be more radical than anything that has happened in the naval and coast defence world for many years.

It is possible that in the new plate the Navy has made answer to the new high-explosive shell.—*Scientific American.*

OIL AS FUEL FOR LOCOMOTIVES.

Most of the roads reaching the recently developed oil-fields in the Southwest are actively engaged in making the necessary changes, or have preliminary arrangements under way, whereby oil will be used as locomotive fuel on the equipment operating locally in this territory. There is economy in the use of oil in comparison with coal in this district, where the cost of coal is above and the quality below the average, but just how much is as yet undetermined from reliable information. Conservative estimates, says the *Railway Age*, place the saving at from 15 to 20 per cent. This reduction is not based on the relative cost of actually producing one horse-power by use of coal or oil as fuel, but involves the comparative cost of the handling of both, and it is from this source that the greater proportion of the economy must be looked for, as in some instances the actual cost of the amount of oil used for fuel has exceeded the cost of coal in performing similar service. This may possibly have been due to improper combustion, but it illustrates the fact that care must be taken in the selection of the proper appliances for using oil to effect an economical consumption. W.

PHYSICAL SECTION.

Stated Meeting, held Wednesday, May 28, 1902.

The Culture Value of Physics.

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Culture is a polyedron of very many faces. It is a crystal that changes its aspect as it changes its position relative to the observer. In order, therefore, to describe it, we must give separate consideration to each of its different parts. This statement, however, does not exempt one, who wishes to treat of it, from endeavoring to give some distinctness to its general configuration.

The word "culture" is so vaguely used, not only by the masses but by educators as well, that it seems like a faint and distant light in a dark and dreary cave, shining uncertain and shading into a misty night. The word is most commonly used in a vague contradistinction to knowledge. The acceptance of this meaning exerts a very pernicious influence, for it frequently gives rise to the belief that the more useless the work the more thankless the task, and the less the knowledge derived the greater is the mental training received. The most striking corollary of this is the absurd "Discipline of Difficulties" which would have us, somewhat in the manner of the ant, back with our burden over every obstacle that can be found in a circuitous path. For the present purpose I shall consider the culture, discipline, training, received in an intellectual pursuit, as the indirect or mediate as distinguished from the direct or immediate use of knowledge; or to express it differently and perhaps to shade the meaning a trifle—as the permanent effect on a being of knowledge and of the method of getting knowledge. Having thus endeavored to mark the outline, I shall proceed to examine some of the faces of the polyedron.

Before entering upon a somewhat perilous sea, let me assure you that I am not taking as ballast a departmental psychology. As I am not taking such a ballast, please

excuse us from the disagreeable, cheap and useless task of going through the motions of throwing it overboard.

At the first glance, physics seems to have nothing whatever to do with the training of the will. Indeed, it would be foolish of us to expect it to replace the formal study of ethics, and it would be wrong for us to intrust it with the inculcation of the highest and most refined sense of duty. But a closer inspection reveals the fact that our subject makes a very definite call on the activities. The movements necessitated in the laboratory are of use in regulating random motion, in adjusting means to ends, in cutting off a number of useless adjustments in order that the remaining ones may have greater speed and certainty, and in handing to automatism and semi-automatism simple movements that the attention may be given to the more complex ones. Besides, the knowledge obtained in all departments of the subject induces a response to the higher stimuli, such as the deference to remote ends, the abstract sentiment of futurity, the love of truth and the desire to progress. Where the student is more or less initiated into the spirit, thoughts and inspirations of the semi-recluse (as he is in a pursuit of physics), it speaks well for the effect of his subject on the will when there are few of its votaries suffering from the malignant form of the disease prevalent among the inactive. I speak of asceticism which finds so few victims in an age in which physics counts so many adherents. But we must not congratulate ourselves too complacently, for many of the immunes are inoculated by simple worldliness which causes the motives as well as the work to become not pure, but applied, and substitutes contrivance for investigation. Moreover, there is still a mild form of the disease prevailing, which is shown by the fact that those whose systems are yet unsullied and who seek pure truth are apt to find action in the world at large more or less distasteful.

But surely, it is safe to say that a man's conscience is modified by a pursuit of physics in its several departments. We should all be surprised should a natural philosopher behave like a child or like one untaught. Even a very imperfect habit of investigation and reflection must cause

many acts, which before gave pleasure, to become more or less painful.

In the culture of the feelings as in that of the will, physics plays a somewhat subordinate part. We should not think of its awakening the stronger feelings of love and hate, nor should we expect it to replace the formal study of æsthetics. It, however, addresses the altruistic emotions and aids in producing a truth-seeking disposition. This it does by the investigation of facts and their relations; but this investigation of fact does not preclude the introduction of form. Frequently do we hear it said that one may be legally right and yet morally wrong. Can it also be said that a statement may satisfy the requirements of natural philosophy and still leave an adverse moral conviction? Is it at all possible that what Sidgwick calls the *cosmic emotion* is partly composed of sentiments *ultra* and sentiments *infra* physical? "Ultra" I use to refer to the higher complex speculations, and "infra" to refer to those emotions of everyday life which are so unscientific and yet so persistent. Lotze says: "I do not think that physics does aught to resist intuitable fact; it merely insists that all investigation be carried on by its own laws." Let us claim indulgence long enough to inquire whether it be for the best permanent interest of truth for physical science to impose its laws on all other branches of inquiry. Can there possibly be other fields of knowledge requiring other postulates and other modes of research? This is mere fanciful speculation; but, if it be at all legitimate, there is a field of inquiry to the emotions of which physics contributes no positive aid.

If physical laws apply to all things, our science needs improvement in cultivating those nicer sentiments in which its devotees are often so signally weak. There is "a time to keep silence and a time to speak," and moreover, there are occasions when it is well to soften the harsher truths of everyday existence. One's finer feelings should free him from the brutality of unseemly and unnecessary truth. A man is a boor who is constantly blurting uncalled-for facts. It is by a mind cultivated by many classes of truths that the human being receives due consideration as a factor in

the progress of humanity. Individual feeling must sometimes be set aside for truth's sake, just as individual life must be made subservient to the life of the community. However that may be, it is certainly true that the feeling as well as the life of the individual is deserving of recognition.

This consideration of the feeling for others' feelings brings us to polite culture. It is but little positive aid that our science renders here; but, in behalf of the science, be it said that arduous work in the field of fact and stern reality must ever tend to keep one from being cultured past his powers and so becoming effeminated. To be cultured without being wise is of little use to progress; and is, in many respects, like being brave without being strong. Over-refinement may over-awe timid men and those unskilled folks who seek superiority in others and ever look for some one whom they can follow; but it must fall before the uncouth strength of stern unvarnished truth. In this way will be lost the good derived from those facts that are fearlessly true, yet softened, gentle, and mild. Let us step out of our own field long enough to pick a specimen for demonstration. The study of ancient wars as pursued in the classics tends rather to produce a Brummel than an Achilles; but the pursuit of tactics and the experience gained in manœuvering troops produces the practical man of military affairs who is needed to-day more than either the modern beau or ancient hero. If an efficient learner in military affairs has polite culture commensurate with his other qualities he will become a gentleman and a soldier. If a military student's refinement is beyond his skill, he will be made an object of imposition. If his culture is below his other powers, he may succeed in military affairs, but he is apt to make war more brutal than it needs to be at this stage of human progress. The function of physics in polite culture is now more easily set forth. It consists in restraining and strengthening so that more refinement becomes possible without the danger of enervation.

Our science begets a liking for knowing things that are so. It does this through the feelings by showing man his welfare at stake. Moreover, the sentiment produced is

neither spurious nor pedantic though it may be crude. One actuated by a spurious feeling of the type which I at present have in mind cares not so much for learning as for the emotions of learning. Who has not seen a student toiling daily to obtain not an education as he himself may fondly fancy, but to obtain the sensations that come with the getting of an education? That nice little woman so often seen in trains poring over foreign verbs and participles would never do anything with that language if she should get it; but, alas, she will never get it! Next year it will be another language or something else. She hears of the culture value of language and she feels the influence of this culture much as one hypnotized tastes what he is told to taste. She wears a dreamland halo and lives in a self-sanctified atmosphere. How much better she feels herself to be than her dancing and more frivolous sister! Her emotions are cheap, but they are spurious. And yet she is so nice and does so little harm we needs must like her.

Of the pedant there is no need to speak: we all know him and dread him. Speaking very generally we might say that literature, when its highest and most remote end becomes too little removed from the mere task of the moment, produces pedantry. Under the same conditions language begets spurious feeling; and science, boorishness.

Our sensations give to us a certain mental tone or modality, which modality, persisting, influences the feeling-tone received from succeeding sensations. This is also true in the higher intellectual realms. Each fact acquired leaves a mental taste, and these tastes taken together produce a liking in the individual which continues in the race. In the field of knowledge we have well-marked inclinations which form our intellectual temperament or disposition. Men collect facts of a certain order just as botanists collect plants. Some of us like or dislike truth just as others of us like or dislike poetry or music; that is, there is a truth-loving nature just as there is a poetic or musical nature. With different individuals the same piece of knowledge may not conform to the same end. Two students master the same discussion; the first feels satisfied on account of

the gentle flow of emotions accompanying the discovery that certain new facts by dint of toil have, at last, come to agree with previously acquired facts, although at first they did not appear to harmonize. The second student is elated because he feels himself to be so clever, because he can strut and pose, and because he sees a possibility of prevailing against some mortal of weaker clay. The emotions of the second are degrading and spurious.

This sickly imitation, however, is not the only cause of one's failing to receive the full emotional benefit of a piece of knowledge. Many facts fail to enter our temperament at all, or else fail to change our disposition in any due proportion to the time and labor spent in acquiring them. Much of moral instruction falls upon deaf wills, æsthetics frequently shows its beauties to blind emotions, and knowledge often seeks response from dumb intellects. The most beautiful poetic passages may fail to change one's attitude towards his neighbor. The higher refinements of oratory are to most people but "a thing apart," and even the noble lessons of example become ours, "as it were, in sort of limitation." The truths of philosophy are acquired by many a toiler who regards them as entirely external to the needs of everyday existence, and "such outward things dwell not in the desires."

If we consider the sentiments of the average pupil after he has pursued a course in physics, it will become apparent that the truths set forth do change, modify, or enter the temperament. This is, in part, due to the fact that the teachings do not take up the cudgel with egoism. If a student learns that water in boiling faster has no higher temperature, he has his feeling toward nature changed, and he cherishes no fond hope that he can break nature's laws as he does when he is about to eat a choice morsel of indigestible food. By virtue of the absence of this personal element in one's bearing toward velocity, ductility, elasticity, etc., he has his disposition somewhat changed by the understanding of these notions. Not entering the lists with egoism, however, our subject cannot conquer save by very indirect means. Natural philosophy commands no force of

moral suasion to cause us to despise and refrain from degrading egoism or disgusting gossip. It does, however, have an excellent opportunity to wean the young student from things concrete, presentative, and unclassified. It so skilfully trains the beginner in the spirit of independence that he is able to walk alone before he realizes that he is not bearing on the outstretched hand of the master. The danger here is the acquiring of a spirit of self-sufficiency and intolerance. This is to be overcome by cultivating the love of production.

In regard to the effect of science on our nature, let me observe that it cannot suddenly make us what we are not. It goes where men push it, and so long as men are arbitrary, conventional and intolerant, science must be more or less so. We are justified in making even a stronger assertion. Science is not much ahead of the people any more than government is much ahead of the body politic. If a great man or a great movement does stir the populace for a time in its attitude toward truth, the man, the movement and the emotion are constantly beset by the danger of going the way of the world. And this way of the world is too frequently in deep ruts and along narrow grooves.

This brings us to the distinction between real and conventional culture and to the realm of the intellect. There are those who have the audacity to imply and even the hardihood to assert that culture is the ability to see the beauties in literature. Such people know not even what *literary* culture is, much less do they know the meaning of culture in general. If we have our better parts well developed, shall we not be able to see the beautiful, the strong and the true? For the development of all of these parts training in special lines is, indeed, necessary; but in the course of instruction the teacher is apt to lay too much stress upon technic and mere conventionalities. In regarding the adornments made by man, we often lose sight of the simple beauties of nature.

Too often the enjoyment received from literary works is due to an acquired and somewhat unnatural taste. I have heard men read, re-read, and chuckle over Kipling, where

he says clever things indeed, but not hilarious ones, and I have been forced to the conclusion that there is a Kipling training. I suppose the abstract of such training received from the different authors would be regarded by many as literary culture. But this is mere polish and not real culture at all. The admiration for turns and tricks bears the same relation to the appreciation of the real worth of the author that the foam bears to the depth of the sea. I think it was Josh Billings who said that "it is better not to know so much than to know so much that ain't so." It is equally true that it is better not to admire so much than to admire so much that is not good; better not to laugh at so much than to be convulsed at what is really not so very funny; better not to go into ecstasies over so many beauties than to be so frequently enraptured by the distorted. This suggests the debt we owe to such men as Ibsen. Indeed, what might be styled the materialistic drama and the idealistic painting have much the same aim; that is, to proclaim the fact that the proper study of art is nature, not art.

But does our subject, which is concerned so largely with fact, possess any of the artificiality which causes one to lose either beauty or truth in the admiration of convention and fad? Alas, strange as it may seem, there is not a complete absence of foam on the sea of physics! Every decade does a number of experiments go the rounds of the schools and colleges, owing their popularity to so slight a cause as imitation, or perhaps even to such a scientific triviality as the fluctuation in values on the exchange of philosophic apparatus. Let one of the great universities introduce a set of experiments for reasons peculiarly its own, and many of the schools and colleges will sheep-like follow. An invention of Edison, accompanied by a bargain-lot of apparatus at König's or Zeise's, would be decidedly felt in the instruction for a few years to come. But are there no more formidable conventions than these? Electricity has had its fads. It is a god, a man, an animal, a fluid. All of these interpretations are more or less anthropomorphic. Stout, in speaking of faculty psychology, says: "It creates an appearance

of explanation without the reality, and in this way seriously retards the progress of science." The same may be said of the assumptions of any science; and, furthermore, it may be said that they tend to create an unnatural standard of excellence. I have known the ability of a scientist to be estimated by his power to talk ions. Classic science must have an Ionic dialect. But even further than this physics has its conventions. It is thought to be a science of simple fact and experimental proof, but it is also a science of interpretations, and these interpretations result too often in unsound theory, partial definitions and ill-formed concepts. Rapid discovery has caused us to give too little consideration to the relation among facts. Be this as it may, it is nevertheless true that when a theory is embraced it is not so likely to be treated as a classic work of art in natural as in some other branches of philosophy. Physicists, more than some other scientists, realize that the proper study of science is nature, not science. Furthermore, although physics does not seek the substance to the entire exclusion of the form, it tends to create a disgust for the meaner conventionalities of life. It is here that our science exerts one of its greatest influences on everyday existence.

In the qualitative element of a sensation physics is strong, but it is not so strong in the quantitative element, in so far as this element is an immediate intuitive estimation of the senses. Indeed, our science does not trust the senses to bear much quantitative testimony. One of its beauties consists in the reduction of sense quantity to sense quality. In this process of reduction space and time differences figure conspicuously. The quantity of the impression made on the end organ is not, therefore, intrusted with the quantitative element of the experiment. The eye may be trained to distinguish more minute differences of position, but there is very little training given in distinguishing the different intensities of light. Moreover, in the higher exactitude of measurements, much of the increased refinement is due to device. The senses in general, however, are so constantly used in investigating the properties of things that they, together with the power of

verbal expression, the interest and the attention in matters pertinent, must be disciplined.

The training of sense-perception is very efficient. The impressions are readily worked into higher mental products, but the reins are never given to simple dreamland fancy. In watching demonstrations or in experimenting, the pupil must relinquish any tendency to withdraw from the external world and to follow a train of his own ideas. Yet he must interpret his sensations in order to keep them consistent with the object to be attained. Thus do opposing elements exert on each other a wholesome restraint. Well-balanced and controlled intellectual activity is employed when the student stops observing to reflect on the work in order to determine whither the data lead, to correct error, or to imagine the conditions necessary to produce a desired result. The referring to externality at each conclusion leads to a culture which is difficult to obtain elsewhere.

In the formation of certain important concepts, and in the exercise of judgment in accepting and rejecting qualities in concept-building, physics is very, very strong. It is not so strong, however, in making these notions complete and definite, although it may render them adequate to its immediate purpose. For instance, it does not stop to discriminate between mass and matter before setting forth the methods of weighing. And although "space" becomes more explicit by virtue of the delicate space relations impressed by the use of the micrometer and similar instruments, our subject asks not whether space is an intuition, a postulate, or an abstract of experiences. In applying the concepts formed to contrivance and to experimentation, physics is strong, but it is weak in pointing out the bearing of these concepts on the complex affairs of life. Thus "time" is rendered more complete by virtue of its constant use in the second and parts of a second, but the value of time is not inculcated.

It would be impossible within the space-limit to discuss, even imperfectly, the concepts set forth by physics, for they are, indeed, numerous as well as they are important. Motion, momentum, force, energy, work, potential, inertia,

radiation, are but a powerful few culled hastily to represent dozens of giants and thousands of the lesser sort. It seems like imposing on credulity to ask one to believe that in courses in which physics is almost entirely neglected branches depending for their treatment on the concepts formed in the despised subject are quite thoroughly taught. Yet, as hard as this is to believe, it is none the less true. Why, in one of our neighboring cities the study of physics and chemistry has been so curtailed that it seems as if the good folk of the place expect to hear a mystic voice crying "great Nature is dead." Verily, there is something rotten in Denmark besides actors.

In explicit qualitative judgment physics is not so strong as her sister science, chemistry. Quantitatively, however, physics is strong, and, taken with chemistry, gives valuable training to the judgment.

Of formal syllogistic reasoning our subject makes very little use. In fact, one of its characteristics is its dependence upon immediate inference or upon the simple detection of similarity among products of judgment. Of the tricks and thrusts of the logician it steers clear; and, while disburdening its champions of the somewhat cumbersome armor of astute opposition in order to allow them to make quick and skilful attacks upon some of the prejudices of the day, it trains them not in the defensive art of disputation. The student of natural philosophy, however, is in no wise loath to try his growing powers in drawing conclusions from the truths he has been taught. Deduction is further drawn upon in the derivation and the application of formula.

If physics and its allied subjects do not stimulate induction, there then is no place within the walls of the school where this form of thinking is awakened. When complete inductions are not made in the laboratory, the fault is in the want of time and the lack of definite aim of the teacher. In work of investigation inductions are natural, healthful, and conservative.

For well-balanced intellectual activity there needs to be a cohesion and interdependence of concepts not only in the

construction of conscious acts of judgment and in the production of higher concepts, but also in the formation of a background to primary consciousness. When constituted by the facts of nature and their derivatives, this background keeps one from going greatly astray. The hypnotized subject loses his bearings, but the true scientist in his normal mood, by virtue of what he has thought and by virtue of what he has acquired, knows, as the Senator would say, "where he is at." But the contribution given to the proper cohesion of ideas by the science of to-day is somewhat lessened by convention; that is, the correspondence of the internal to the external would be greater in an ideal Emile than in one brought up on "science as she is taught." In spite of all, however, science tills well the soil into which the seeds of individual facts are sown. One of the main differences between a scientific man and a fact-monger consists in the interrelation among notions.

This cohesion of ideas or background of consciousness may well be called the Intellectual Resultant. If a body moves in conformity to the resultant of a number of forces, and still another force enter the scheme, the motion will be proportionately changed; but if the new force merely cross the path or if it detach a small part of the body, the motion of the main body will either not be changed at all, or changed in no due proportion to the magnitude of the new force. A parallelism can certainly be drawn between this and facts entering the mind, for the latter may either cross the path or act upon the intellectual motion or tendency. What temperament is to the feelings, what conscience is to the will, resultant is to the intellect.

Elementary physics, employing, as it does, sensation, perceptions and fundamental notions, must do much to modify our mental attitude, and a further study of the subject must give us a scientific bearing. It is true, however, that a fact may take part in the scientific without taking an equivalent part in that general resultant which bears on perfect living. For instance, a man may acquire the habit of suspending judgment in experimentation, and yet he may not hold in abeyance his opinion where he has heard a few trivial and

unproved facts in regard to his neighbor. Our bearing towards the everyday and smaller affairs of life gives evidence of our deeper natures, which natures find their training not only in gentle habit, but in the ways that stir the soul.

It might not be out of place here to say a few words in regard to suspended judgment. The cautious habit of waiting for data before coming to a decision can undoubtedly be trained by physical experimentation; but at present that acquired in the elementary work owes its principal debt to the lecture, the classroom, and the verbal part of laboratory instruction. It is by no means an easy task, in the time which we have at our disposal, to force the general student of physics into the attitude of investigation. The pupil knows when he is set to prove a fact, and, on such occasion, he will not play that he is not. In measuring distances his attitude of investigation is too apt to be spoiled by the idea of true length. This he frequently tries to determine, first, by asking questions, and second, by measuring. Have you not heard him ask of his teacher, "What is the distance?" and of his fellow, "What do you get it?" He should have it impressed upon his mind that the true length, according to his sensations and perceptions, is what he himself finds it to be, and that, in the case of primary experiences, to go on hearsay evidence is to cheat science and to impoverish the intellect. If, by better work, he is subsequently enabled to detect minuter differences, he should know that this improvement in discriminating power has made him a better being. Secondary knowledge, he should learn to see, depends for its interpretation upon experiences, and that the laboratory is the place to get some of these experiences and the place to learn how to get others. After all, things are to us what our sensations and perceptions determine them to be, and the world inside of the laboratory as well as outside of the laboratory is ultimately to the individual precisely what he gets it for himself.

The same statement cannot be made with regard to the advanced study of physics. In the laboratory the student investigates, and in the classroom he criticises. The knowl-

edge in this case, however, is not so likely to enter into the intellectual resultant and to modify the temperament in proportion to cost of acquisition as it is in the elementary study. The advanced concepts are too complex to be applied by any but a philosopher to the affairs of everyday existence. In fact, they sometimes fail of application to the work in hand. I have known a student in reproducing the explanation of an experiment to work out two mathematical expressions side by side and to neglect, at the end, a desired substitution, showing thereby that he has lost the very crowning point of the experiment. He may be instructed and re-instructed, drilled and re-drilled until he can end the story properly, but he will be as little cultured by the pretty trick as an animal is cultured by learning to walk on its hind legs. This student had reached his limit of complexity in notions of this order. I know of a very scholarly and original man in the province of the humanities who is unable to understand the higher mathematics. His marked success in his chosen field proves the more complex mathematical concepts to be beyond his needs. Of course, he might be better off if these notions formed part of his mental background, but as his mind is constructed he would waste time if he pored over the calculus. He is too wise to do this. If he had been stupid, pedantic and spurious, he might have gone on with his formulæ and fancied himself a mathematician, for he would not have been able to see that these higher concepts were taking small part in his intellectual make-up. He might even have fancied himself to be receiving important culture, because, forsooth, he lay awake all night, and in the early morning dozed off only to be haunted by dreams in which he saw the sign of integration chasing a trigonometric function around the garden, while off in one corner he beheld a mean little differential taking advantage of the order of things to tease the even root of a negative quantity just because the latter could not get out of its box.

There is a qualification that I must make here in order to explain my position. Our power of symbolism runs ahead of our power to give mechanical explanation. We letter our machine, add, multiply, subtract, divide and

substitute the letters, paying little attention to the mechanism until we apply the result. The mind no more follows definitely each move that the working of the formula means than it follows each rotation of the wheel. If we were to lay aside formulæ until we could understand all that they mean intuitively or mechanically, we should lay them aside until we could get along without them. But although we cannot always see clearly the relation of symbolism to phenomena, we should be able to understand the inter-relation of symbols.

So far we have considered the pupil. What truths of culture does the master teach? It seems too bad that the experimental scientist, with his highly trained powers of observation and judgment, does not take more interest in the affairs of general human progress! What a restraining influence he might exert on the popular passions! How excellently well he could veto those measures which threaten to become laws merely by virtue of their addressing themselves to spurious sentimentality! How much harder it would be to fool all of the people some of the time if scientists were ever awake and active in matters concerning public weal and woe! The love of truth and a feeling for the eternal fitness of things characterizes the scientist in his special toil; would it not be well for humanity if he could and would assert these qualities at the polls, and in public debate, and in other ways aid in subordinating popular impulse to social principle? But, alas! we cannot claim for a specialist the full culture of his subject! When one becomes involved in an investigation of a class of facts limited in range, he must become unduly developed in certain mental activities. This fault, if fault it be, is due to specialization of social function and not to any department of human knowledge. Each man has his limit of general mental growth, and, when this is reached, development must be along particular lines. The scientist of to-day can no more be blamed for not knowing the full bearing of his higher concepts on perfect living than can Thales be blamed for not realizing the practical possibilities of electricity. A scientist, on account of the nature of his work and on ac-

count of his peculiar temperament and intellectual make-up, needs to be somewhat released from the lower thoughts and lower needs of mankind. It is true that he must be a man as well as a specialist, and, as a man, he must have needs as well as duties; but for his highest work he must be stimulated by thoughts and emotions that refuse to be interpreted into terms of avarice, passion or sensuous enjoyment.

It would seem, on consideration of the hard names sometimes bestowed by one physicist upon another, that the subject did little for the spirit of free discussion. In as far as this is true it is due to a limited view caused by that high specialization which confines each laborer to a short and narrow field. Though this tendency to restrict one's view to his own kind of work is true of all subjects, it is especially true of natural science. Science is too indifferent to its standing in the community of subjects. Surely it is a grievous fault, and grievously hath science answered it. Its adherents have been so negative in educational matters, for instance, that they could almost be regarded as positive. Most of them bestow upon the consideration of correlation of subjects and of culture a magnanimous amount of icy neglect. By constantly measuring all men by their assumed and careless standards, they chill the enthusiasm of those who would act and enfeeble the voice of those who would speak. It is for this reason that science, with all its powers to train the mind, is so frequently regarded as the mere description of a trade, and that the laboratory is looked upon in much the same light as is the kitchen of a cooking school. If this is true of all science, what hope is there for the establishment of the disciplinary good of physics? Let me usurp the prerogative of an Irishman long enough to say that there are very few interested in the matter, and these care nothing whatever about it.

But it would be surely foolish to expect to establish the culture value of physics by a mental analysis of the physicist. It is proverbially difficult to teach the physician to heal himself, and it is still more difficult to teach him to live according to the rules of hygiene. Whatever be the

reason and whatever proverb be *àpropos*, it is still a fact that among professionals is a poor place to look for culture. We recognize this with regard to athletics, but not with regard to studies. The reason the professional athlete does not always make the best trainer is that he is apt to view his particular game or specialty as an end in itself. This difficulty may be, in a measure, obviated by careful co-ordination. And here is to be found a needed lesson for scientists; for the spirit of professionalism is impairing the grade of work and lowering the standing of the worker. When professionalism comes in at the door, culture goes out at the window.

In conclusion and in my own behalf let me add that I have tried to treat of physics in particular and of science in general as they exist in the curriculum of to-day. It would be impossible to describe our highest ideal and, at the same time, to maintain the dignity of philosophic language. As a department of human knowledge unclouded by fad, unstained by prejudice, untainted by any age or any locality, the importance of science is in no danger of being overrated. Out of doors, away from the influence of the workshop and the narrow sentiments of the laborers, who are hampered by restricted environment and exhausted by daily toil, the glory of science is like the glory of the noonday sun, too dazzling to look upon. If the bright sun of science could dispel the mists that at present disperse the rays and color the perceptions of truth there would be very different things to say about the culture value of physics.

TECHNICAL NOTES.

——According to an account in the *Scientific American*, the *air resistance to the rotation of a fly-wheel* may cause a considerable loss of energy. A 450 horse-power engine, direct connected to a generator, has a fly-wheel with channel-shaped arms. The tests were made by using the generator as a motor, driving the fly-wheel up to a normal speed. It required 13,300 watts to rotate the wheel and shaft, but by inclosing the arms in a sheet-iron casing the wheel was driven by an expenditure of 9,874 watts. The saving effected by use of the shield was 5·7 horse-power, or 1·2 per cent. of the power of the engine.

——Prof. A. G. Bell is quoted as predicting that *wireless telegraphy* will never supplant wires in land service on account of the interference of the

various stations. He considers the supremacy of the wireless method much more probable for transoceanic systems. Marconi reports having received messages on the Italian flagship "Carlo Alberto" which were sent from Cornwall across England and a portion of Denmark. The distances were from 850 to 1,400 miles. It is reported that a submarine torpedo boat at Cherbourg, France, fitted with a mast and wireless telegraph receiver, received distinct signals from a central station. The distance is not stated.

——Experiments made in the physical laboratory of Cornell University showed the production of 116 grains of *liquid air* by 1 horse-power in one hour. Only 2 per cent. of the energy expended is stored in the liquid air.

——Interest in the *Edison storage battery* is awakened anew by the practical tests which have been recently reported. A light runabout with twenty-one cells, weighing 332 pounds, made a run of 62 miles, climbing grades of 12 per cent., and at the end of the trip the battery was capable of driving the vehicle at 83 per cent. of normal speed. On a smooth and quite level road the carriage covered 85 miles on one battery charge. Five automobiles are being built to run 5,000 miles each on a test. It is expected to cover 100 miles on a charge.

——According to *Engineering News*, a special *trolley car for conveying fire-engines* is in use at Springfield, Mass. The engine is carried on a platform only 9½ inches above the top of the rail, mounted on a truck at each end. The front truck is detached and the front end of the platform lowered to the ground when the engine is to be loaded on the car. Platforms over each truck afford space for firemen and equipment. The length of the car over all is 30 feet 10½ inches, and its net weight is 14,000 pounds. The Springfield Fire Department has loaded an engine on one of these cars in two and one-quarter minutes from the time the car was in position to its being ready to start, and has unloaded an engine and attached the horses to it in one and one quarter minutes.

MAGNETIC DISTURBANCES IN THE UNITED STATES COINCIDENT WITH MT. PELEE'S ERUPTION.

A communication to *Science* by Superintendent O. H. Tittmann of the Coast and Geodetic Survey, refers to a magnetic disturbance which was noted at the United States magnetic observatories in Maryland and Kansas on the evening of May 8th. The disturbance occurred at practically the same instant at these two widely separated points, and the phenomenon appears to have been very nearly coincident with the eruption of Mt. Pelee. The following is quoted from Mr. Tittmann: "Purely mechanical vibrations caused by earthquakes are often recorded by delicately suspended magnetic needles. The disturbance of May 8th, however, was distinctly a magnetic and not a seismic one and hence was not recorded on seismographs. Until further information has been received from other observatories it cannot be determined definitely whether this magnetic disturbance was due to some cosmic cause or came within the earth's surface."

Mechanical and Engineering Section.

Stated Meeting, held Thursday, December 4, 1902.

Roman and Pre-Historic Remains in Central Germany.[1]

By Edwin Swift Balch.

In Central Germany, in the province of Hesse Nassau, there are numerous remains of the Romans and some even more interesting ones of the primitive Germans. German archæologists have given a good deal of attention to these remains during the last quarter of a century; and they have brought to light many facts in connection with the early history of man in Germany.[2] Passing over the times of feudalism, when the barons planted their strongholds on many a steep hill, and going back to the beginning of the Christian era, one finds that about the middle of the first century A.D., the Romans invaded the plains of Hesse Nassau, then inhabited by Germanic tribes, and established themselves south of the Taunus. The Romans soon found the need of protecting themselves in their new "sphere of influence" and they erected a line of fortifications from the Rhine to the Danube. The peasants formerly called this

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[2] This paper is based partly on considerable personal observation and partly on the books, papers and verbal statements of the Königlich Baurat L. Jacobi, who has devoted his life to the exploration of these remains, and whose writings are a mine of information. I wish to express my indebtedness to this distinguished German archæologist.

Among the publications about Roman remains in Germany, are :

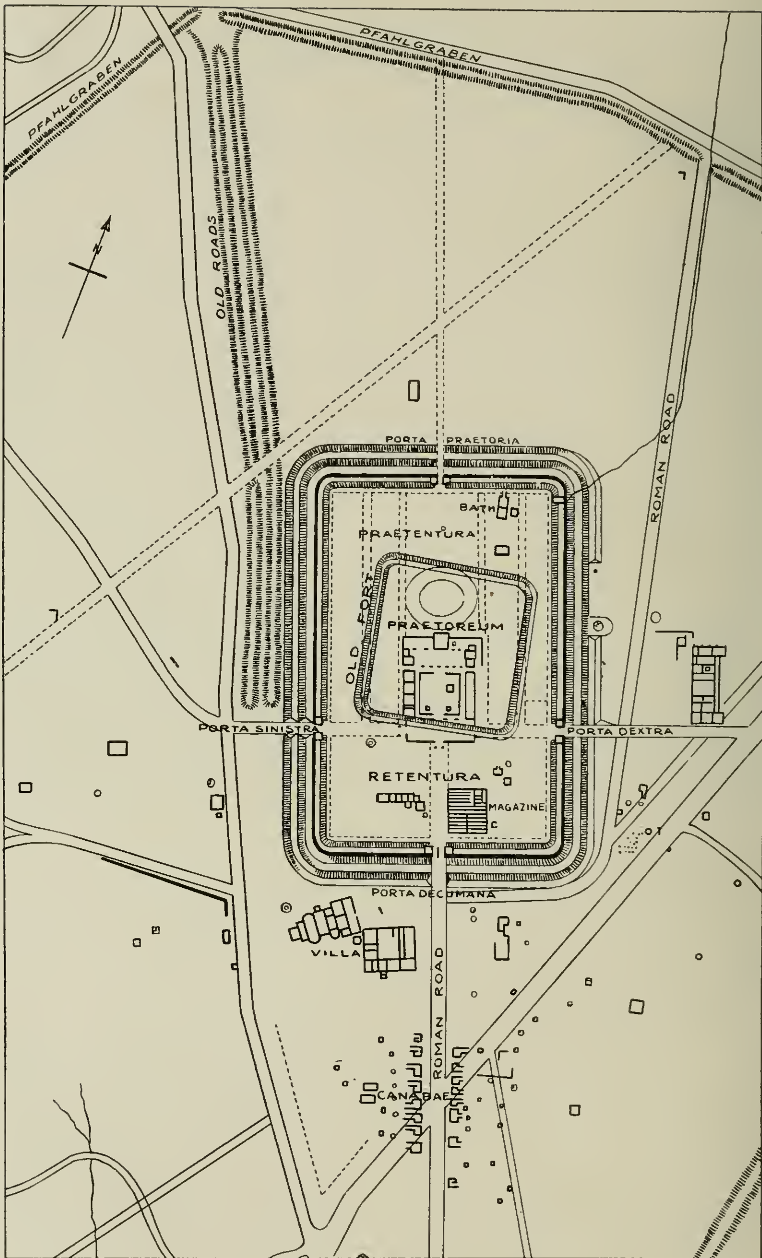
Jacobi, L. Baumeister : "Das Römerkastell Saalburg bei Homburg vor der Höhe," Homburg vor der Höhe, 1897. One volume, with maps and plates separate. This book includes an exhaustive bibliography.

Cohausen, A. von : "Der Römische Grenzwall in Deutschland," Wiesbaden, 1884.

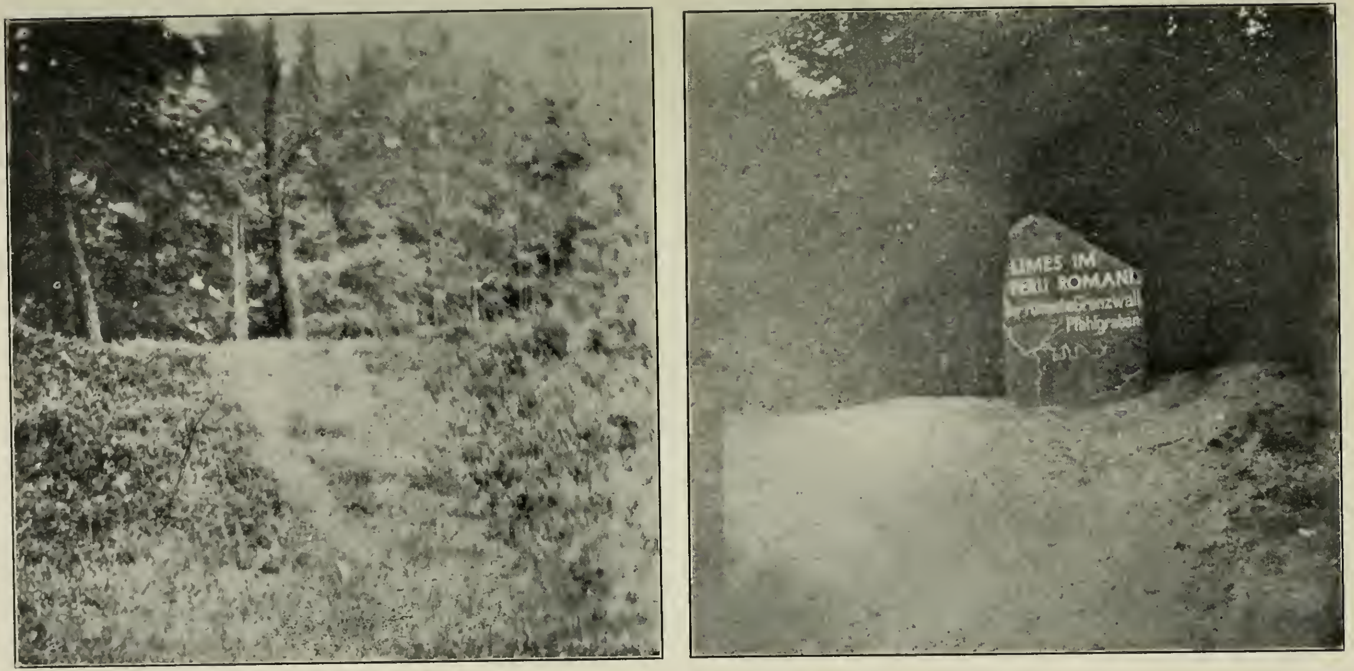
Cohausen, A. von, and Jacobi, L.: "Das Römerkastell Saalburg," Homburg vor der Höhe, Staudt & Supp, 1902. Guide Book.

Blümlein, Karl : "Die Saalburg," 1901.

Schulze, Dr. Ernst : "Römisches Soldatenleben in den Taunus Kastellen," Frankfurt A.M., H. Berchtold, 1898.



THE SAALBURG.
From the maps of Baurat L. Jacobi.



On the Pfahlgraben.
From photographs by Miss Nora Hamilton Coote.

the Teufelsmauer, but it is now known as the Pfahlgraben, a name explained by some students as meaning a boundary, while others consider that it comes from the Latin *vallum*. The Pfahlgraben consisted of an earthen wall, and in some places of a wall and a ditch, and it can still be followed with ease throughout most of its length, especially in hilly and wooded places, where peasant farmers have had no opportunity of leveling it. The Pfahlgraben, which is about 542 kilometers long, begins near Hönningen on the Rhine, follows roughly the watershed of the Taunus Range, and after making a big curve northward, strikes the Main a little east of Frankfurt. It starts again at the southerly bend of the Main, goes some distance nearly south, and then almost due east a good distance to the Danube, which it reaches near Hienheim in the neighborhood of Regensburg. Although it is not known exactly when the Pfahlgraben was built, nor when it was abandoned, yet it is certain that it was constructed by the Romans, and that during portions of the first three centuries of the Christian era Roman soldiers stood on guard upon it. The Pfahlgraben, which from a political standpoint was not unlike the great Chinese Wall, was undoubtedly mainly intended to ward off the attacks of the unsubdued tribes of Northern and Eastern Germany, of whom the Chatten and the Allemannen were the most hostile; but it must also have been used as a tariff frontier, to levy tribute on any persons who crossed to the south. The reasons for locating a part of it north of the natural frontier of the Main are not self-evident; still it is noticeable that the mineral springs of Wiesbaden, Homburg and Nauheim are south of it, and the desire to profit by their beneficent waters may have been one of the causes which made the Romans enclose this country. For a time the barrier appears to have served its purpose, until, with the increasing degeneracy of the Roman empire, the sturdy northern barbaric element overwhelmed the enervated southern race.

Behind the Pfahlgraben, at comparatively short intervals, were about eighty large and small fortified camps and towers, where bodies of troops were held in garrison. The

most important of these posts in the Taunus are known as the Kapersburg, the Zugmantel and the Saalburg. The latter, situated in one of the gaps of the Taunus, overlooks Bad Homburg, from which it can be reached in half an hour by trolley. It is now being restored entirely, but as late as 1872 it was little but a ruin in the forest, where only the foundations of fortifications and house walls and a few holes in the ground were visible.

There do not appear to be any written records from Roman times of the Pfahlgraben or the Saalburg; neither are there any legends connected with them, and the valuable help to history, therefore, occasionally afforded by myths, is in this case wanting. Our present knowledge is based practically on the remains of the foundations and on the relics found among them. But little as we know of the history of these old fortifications, yet there can be no doubt that the Latins and the Teutons once struggled for supremacy along them, and that the former were conquered and retired. And as one follows the lines of the Pfahlgraben and the ruined Kastells one cannot avoid the reflection that a great empire, advanced and civilized though it was, but with its members weakened physically and morally by centralization and the destruction of individualism, could not withstand the assaults of a ruder but stronger race, with its units undeteriorated by overcrowding and overgovernment.

The name Saalburg may come from the word *saal*, meaning hall, or *sal*, meaning boundary, but the origin of the name is still uncertain. The first writer known to use the name was the Homburger, Elias Neuhof, who mentions the Saalburg in a letter in 1747, and who wrote a short account of it in 1777. He saw it still in a state of tolerable repair, although it had served as a quarry of ready-cut blocks of stone to the neighboring peasants, and although many of its stones had been carried off for building the castle and the Lutheran Church at Homburg in the seventeenth and eighteenth centuries. It was only in 1818 that the taking away of the stone was stopped, and not until 1853 that the first diggings were undertaken by the antiquarian, F. G. Habel. In 1870, Colonel A. von Cohausen was entrusted with

THE PORTA DECUMANA, SAALBURG.

The Atrium, Saalburg.
The Emperor of Germany has Baurat Jacobi at his right hand.

the excavations and repairs at the Saalburg, and in 1871, Königlich Baurat L. Jacobi joined him, and under his guidance the work is still carried on. The Homburg "Saalburg-Verein" furnished some of the money, the Emperors William I and Frederick III likewise assisted with funds, and the present sovereign in 1897 ordered the reconstruction of the central building. The rejuvenating of the Saalburg is progressing slowly but steadily, and each year sees a certain amount of reconstruction carried out, as well as a certain number of archæological finds. Every care is taken to insure the utmost possible accuracy in reconstruction. Roman camps similar in character have been examined in other parts of the world, for instance, near Fréjus and Cannes in France and near Lambæsis in Algeria, and these have been followed in many details. Roman authors, like Cæsar and Tacitus, have been studied diligently for every passage which might bear on the subject, and it is safe to assume that the new Saalburg will closely resemble the original. Certain persons take exception to the rebuilding of the Saalburg, but it may be well to suggest in rebuttal that no ruin would give the same impression of reality as the restored building, and, moreover, that there are some seventy-nine other camps of the same kind in a state of ruin.

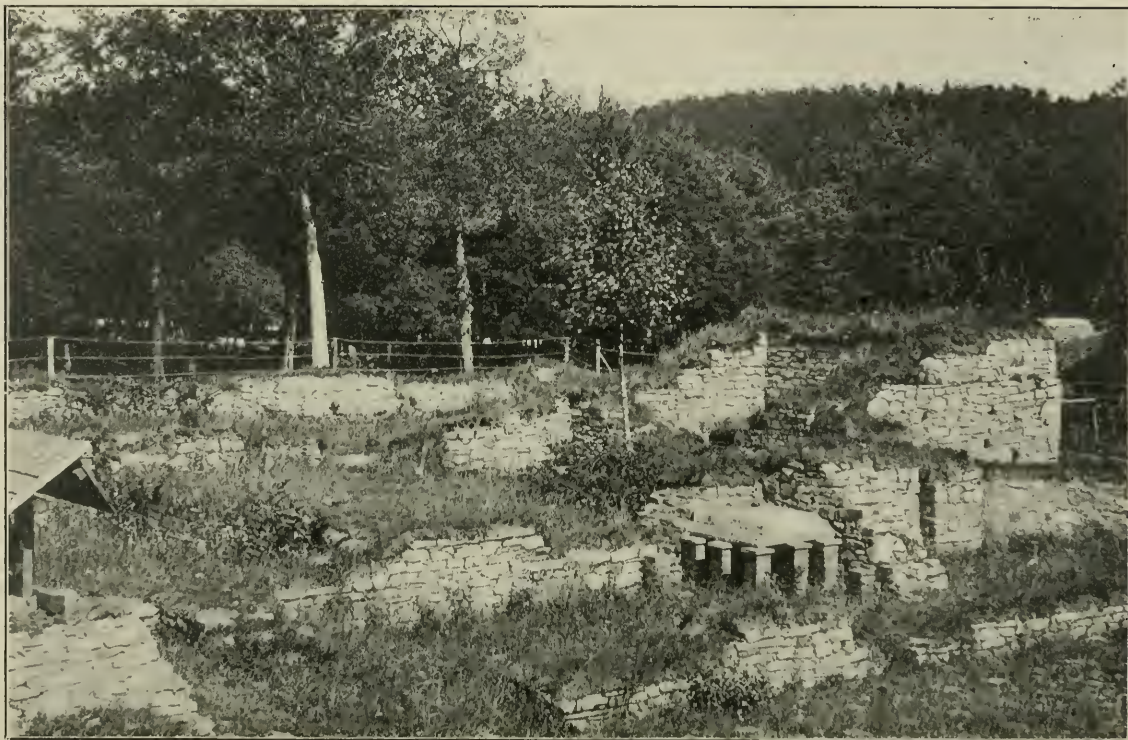
The Saalburg was a fortress, but one practically constructed on the lines of a Roman military encampment, and it may perhaps better be designated as a permanent fortified military camp than as a fort. There is little doubt that, in the order of time, there were three permanent camps at the Saalburg. The first was probably an earthwork, and was much the smallest. The second, it is believed, was of wood and was probably destroyed by fire, possibly after a fight. Various remains have been discovered leading to these conclusions. The third camp was built almost on the lines of the second and was surrounded by a stone wall whose outside dimensions were 221·45 meters in length by 147·18 meters in breadth; that is, the sides had a relation of 2 to 3 The wall was about 2·50 meters in height and was crenelated, to allow the legionaries to hurl their *pilums* or throw-

ing spears through the openings. On the outside it was surrounded by a double, probably dry ditch, while on the inside it was banked up with earth, forming a platform for the soldiers to stand on. On each side was a gate: to the south the Porta Decumana, to the north the Porta Prætoria, to the east the Porta Dextra and to the west the Porta Sinistra. The Porta Decumana had a double entrance and the other three only one each, and each of these gates was flanked by two small towers. The northern and southern gates were in the middle of their respective sides, while the eastern and western ones, through which it is believed the troops made *sorties*, were at one-third the distance from the southern end and faced exactly the doors of the main building.

The southern wall and half of the eastern wall, and the Porta Decumana and the Porta Dextra are already rebuilt as well as the Prætorium within. Over the outside of the Porta Decumana is an inscription: "Guilelmus II Frederici III Filius Guilelmi Magni Nepos Anno Regni XV in memorian et honorem parentum castellum limitis Saalburgense restituit." In front of the gate is a statue of green bronze with some gilt decorations: it is by a German sculptor, I. Götz, and is inscribed: "Imperatori Romanorum Tito Aelio Hadriano Antonino Augusto Pio Guilelmus II Imperator Germanorum."

The interior of the Saalburg is an almost level rectangular space which slopes gently towards the north and in the center of which is the Prætorium. The southern end is spoken of as the Retentura, the northern end as the Prætentura, and the eastern and western parts as the Latera Prætorii.

The Retentura, which was farthest from the enemy, was the place for the commissariat and quartermasters' departments. In the eastern half are the remains of the Horreum or provision house, as is demonstrated by the cross walls still remaining and the hooks for hanging meat found there. In the western half of the Retentura are the remains of what is called the Quæstorium, which may have been the officers' quarters.



Foundations of the Villa, Saalburg.
With the remains of the heating apparatus.

The Prætentura, at the northern end nearest the enemy, was the quarter of the soldiers, who lived there either in tents or in wooden huts. Here, somewhat sunk in the ground, is a small circular ring, which was at first supposed to be an amphitheatre; but as many horseshoes were found there, it seems most probable that it was a riding ring. At the northeastern end of the Prætentura are the remains of a bath which dates back probably to the earliest earthwork camp and which does not appear to have been used at the latest period. This bath consisted of two main parts. One with a seat in it was a cold-water bath. The other was heated from underneath and was subdivided into two portions, of which one was a warm-water bath and the other probably a hot-air bath.

The Prætorium, which is 60 meters long and 40 meters wide, is in the position where the tent of the commander was placed in a flying Roman camp. It is now almost restored and is to be used as a museum for the various finds. The southern end is a big wooden-roofed hall with stone walls in which are two stories of windows of which the upper ones are the biggest. It is supposed that during bad weather the soldiers were drilled and practised in throwing the pilum and vaulting on a wooden horse in this hall. Adjoining this to the north is the Atrium, a courtyard open to the sky and surrounded by a wooden-roofed piazza. In the Atrium are two wells, one with a wooden, the other with a thatched roof, and the remains of a little building of uncertain date and use, but which was perhaps a Sacellum for the first or second camp. On the east and west sides of the Atrium, beyond the piazza, are long narrow chambers and to the north is another smaller court, beyond which are several more rooms. The middle one of these was probably the latest Sacellum, where the military insignia and the statues of the gods and emperors were kept.

Immediately around the Saalburg there are many ruins. To the east and west the foundations of many small houses show that there must have been something of a settlement. To the south are the remains of many Canabæ, *i. e.*, houses of suttlers and camp followers and also drinking shops,

probably not unlike our saloons. Immediately before the western front of the south wall are the foundations of the so-called "villa," which was possibly the house of the commander in peace times, or which may have been an officers' club, and where at the proper season wild strawberries now grow in abundance. There appears to have been a bath here, or at least there is a heating apparatus under one room. From the Porta Decumana a road led south to Heddernheim in the valley of the Nidda, and on both sides of this, some 300 meters from the gate, was a burying ground, where some 350 graves have been discovered. The dead were cremated and the ashes placed in an urn, together with small jugs, pieces of—often false—money and other small articles.

The water supply depended on wells, of which fifty-eight have been found up to date. Eight of these are in the camp. Almost every small house had its own well. The oldest have wooden sides, while the later ones have walls of stone without mortar. The dirty water was carried away by drains or canals, some of which still act.

The heating system was ingenious. A shallow cellar was dug and a number of low brick pillars erected. These supported a floor of terra cotta tiles and concrete. Outside of the house was a sort of oven, which had an opening into the cellar, and the cellar was also connected with the outer air by terra cotta pipes placed against the inside of the walls and opening at the roof or within the room. A wood-fire was built in the oven and the hot air went into the cellar and enough of it rose through the terra cotta pipes to keep up a slow draught. The floor and the walls were gradually heated up and the room was doubtless kept warm for a rather long time.

Many articles have been dug up at the Saalburg, principally under the ruins or in the wells. Some of these are primarily of historic importance. Such for instance are numerous terra cotta slabs bearing inscriptions like the following: "C O H. II. R A E T" (Cohort II. of the Rhetii); "C O H. III. V I N D" (Cohort III of the Vindelicii). These prove that some of the troops stationed along the Pfahlgraben were German auxiliaries, and it may well be

that, tired with the overbearing Romans, when the last struggle occurred, they fraternized with their oncoming relatives and took their share in ending the Roman domination in a turmoil of blood and fire.

Many coins have been dug up, and these give a tolerably accurate means of estimating the duration of the Roman sojourn. Twenty-two coins date from 268 to 30 B.C., a few belong to the reigns of the earlier emperors, but it is in the reign of Vespasian (69–79 A.D.) that they first become numerous, and it was doubtless about that time that the Saalburg was started. There are many coins with the effigies of Domitian (81–96); Trajan (98–117); Hadrian (117–138); Antoninus Pius (138–161); Marcus Aurelius (161–180); Septimus Severus (194-211); Heliagabalus (218–222); Severus Alexander (222-235); and Gordianus III (238–244). The latest ones are of the reigns of Valerian (253–259) and Claudius Gothicus (268–270). It is probably not far out of the way to assume that Roman control of the Taunus came to an end about that time after lasting some two centuries.

Some of the finds are chiefly of archæological and ethnological interest. Such for instance is the pottery in the shape of amphoras, jars, etc., of which much has been dug up; but especially noteworthy are the broken panes of glass of which many pieces were found in the "villa," for they show that in northern climes the Romans used glass windows. The panes range from a light green to a dark-blue color, and they were about 40 centimeters by 40 centimeters.

Among the iron relics the horseshoes are most note worthy. A number have been found in the riding ring, and they show that the Romans, in Germany at least, used them. Shoes for mules and oxen are also not uncommon. The spurs were cleverly made, as the shank did not point straight from the middle of the heel but curved somewhat outward: there was thus no danger of the rider accidentally striking his horse, for he had to turn his toes out and bring his heels well in to spur him. In this implement the Romans were ahead of any other people. Few weapons have turned up, probably because they would be most jealously cared

for from their great value to friend and foe in such a wild region. Tools, on the contrary, are rather numerous, and the hammers, saws, axes, nails—but no screws—are much like those still in use in Germany. A number of the tools are for left-handed workmen. One small garden pick is so exactly like a Swiss ice-axe, that one might almost assert that it was an ice-axe. The works of art are unimportant, consisting principally of a few little bronze statuettes.

Over a hundred and fifty articles of leather have been taken out of the wells, where the mud seems to have acted as an air-tight preserver. The most important are one leather jacket and a number of sandals and shoes. No entire pair of these has turned up, but only worn out single specimens, some shaped like an undeformed foot, but many ending in a point in the middle of the toes.

Of the animal bones discovered, all belong to now existing species, except a few of the aurochs (*bos urus*) and the swamp-boar (Sumpschwein, *sus scrofa palustris*). It is not wonderful that stag and roedeer remains are plentiful, for these animals may be seen constantly in the vicinity of the Saalburg, and the gates have to be barred at night to prevent their coming in to feed. Indeed, Herr Georg Baer of Homburg tells me that some years ago he saw stags fighting in the Saalburg, while the hinds were looking on.

Leaving the Saalburg and following for about 3 kilometers eastward the Pfahlgraben, which there consists of an earthen rampart with a beveled edge and a ditch, one reaches the foundations of the small square fort, now known as the Lochmühle, which was doubtless the post of the garrison which kept guard in the *thalweg* of the Köppern Thal. Continuing along the Pfahlgraben and passing the foundation-wall of a small Roman tower, after about 6 kilometers more through beautiful woods, one arrives at the Kapersburg.

The Kapersburg resembles the Saalburg, but it is not more than half the size, and it is still even more untouched than was the Saalburg thirty years ago. It is surrounded by a ruined wall in which there are four gates. There are the foundations of a prætorium and several other buildings

within, and so far three wells have been discovered. A bath or villa situated between the Kapersburg and the Pfahlgraben is now being ransacked. This has the remains of heating apparatus, and coins, bronze ornaments, pots, etc., are often turned up. Herr Jacobi told me that, as at the Saalburg, remains of three sets of forts in the order of time exist at the Kapersburg. The walls can be followed only with difficulty, and the whole place is hard to examine, as it is full of pitfalls and it is covered with a dense growth of thorny brushwood, in which my companion, Professor George F. Barker, and I once started a roedeer.

Even more interesting and much less known than the Roman remains, however, are those of the early native races. A certain number of their architectural efforts have come down to us, and these are a mute comment in showing the danger these peoples were constantly in from their brother savages. These earliest constructions are the walls —generally of a fairly circular form and hence now called *ringvälle*—which undoubtedly were refuge forts, to which the native inhabitants fled for shelter with their cattle at the approach of an enemy. These ringwalls are generally on hill tops, and, as a rule, are partly surrounded by a ditch. There is no trace of mortar—which was doubtless unknown to the native builders—among the stones of these ringwalls, and it is believed that they were held together by layers of wooden beams, and that it is owing to the rotting away of the latter that the stones have sunk together into long heaps. According to Cæsar, the Gauls built forts with the stones of the walls bound together by layers of wood, and a bass-relief on the Trojan column shows similar forts as in existence among the Dacians. This gives a clue to the date of these German ringwalls. Although they may have been used in post-Roman times, yet they were probably in use at the arrival of the Romans. It would seem likely, therefore, that they were erected by a Celtic or Germanic people in a bronze age, but it is not impossible that they originated long before with a people in a Neolithic stage of development.

Half an hour's walk from the Saalburg is one of these

ringwalls, the Gickelsburg, which is so hidden in the forest that it is hard to find. It is 220 meters by 165 meters in dimension, and the rather small stones have sunk together into a long, oval heap. The finest of these ringwalls in Central Germany, however, is the one on the Altkönig, above Falkenstein, which is in full sight of Homburg and easily accessible. I examined it in company of Professor George F. Barker. This fort has a double line of walls, both in good preservation, which entirely surround the summit plateau of the mountain, enclosing a space several hectares in extent. Each wall, at present, must be some 8 or 10 meters in breadth by about 3 meters in height, so that the original dimensions may be estimated at some 5 or 6 meters in breadth, by the same in height. The stones average in size from perhaps the bulk of an orange to that of a large watermelon, although there are some few bigger ones. They are evidently the mountain stone brought together and piled up, and Professor Barker thought they were all a quartzose sandstone. We saw no traces of wood or vitrification, which latter occurrence, probably caused by fire, is found occasionally in the somewhat similar "vitrified forts" of Scotland. At the eastern base of the Altkönig is the Altenhöfe, another single-walled ringwall, smaller and less perfect than the one on top.

A certain number of the implements of the early Ger mans have also been obtained in the Taunus and in the plains of Hesse Nassau. In 1880, near the Ferdinands platz in Bad Homburg, a great find of bronze implements and weapons was made. Among these are axes or celts, lance-heads, some plaques or bosses for shields, bracelets, sickles, etc. They may date to 600 or 800 B.C. It is possible that some of them were cast in the neighborhood of Homburg itself, but it is probable that most of them were made in Bologna, Italy, and that they reached Germany through regular trading. They would seem to show that the Germanic peoples, for some centuries before the Roman invasion, were in a bronze age.

Neolithic implements also are found in Hesse Nassau. While the smooth-stone axes and tools are not numerous,

yet enough have been dug up to make certain the fact that some thousands of years before the Christian era, savage Neolithic tribes shared the still virgin forests with the aurochs, the bear and the lynx, and that they slowly carried forward the evolution of man in Central Germany. When the use of these instruments began and when it stopped is not known, but in July, 1902, while digging up the earth at the Porta Sinistra of the Saalburg, two small smooth-stone implements were found in the same layer with Roman remains, and this is a noteworthy piece of evidence that the use of smooth-stone implements *may* have continued until the beginning of the Christian era.

A few chipped rough-stone arrow-heads have also been found in Hesse Nassau. The specimens look exactly like North American Indian arrow-heads. They are probably Paleoliths, but the evidence is still meager about the earliest peoples of Central Germany.

Notes and Comments.

TWO YEARS IN ARGENTINE AS CONSULTING ENGINEER OF NATIONAL PUBLIC WORKS.*

By Elmer Lawrence Corthell.

The lecture was introduced by a brief statement in reference to the selection of Mr. Corthell, by the United States Government, and recommended by it to the Argentine Government, to act as its Consulting Engineer for a definite period.

Mr. Corthell was a delegate of the Argentine Government at the International Navigation Congress, at Düsseldorf, last summer, and when called upon to respond for that Government, he opened his remarks by a brief comparison of some of the interesting features common to both countries. This comparison is given in the lecture, and in order to fully appreciate the location of Argentine, some of the most important geographical features.

The lecturer then makes an interesting comparison between the Mississippi River and the Rio de la Plata and its tributaries, in reference to the geologic and hydraulic causes which, in ancient times changed the course and the volumes of both rivers, and, by great sedimentary deposits, made the underwater areas suitable for the habitation of man. Areas of drainage and volumes

*Synopsis of a lecture delivered in the Hall of the Y. M. C. A., Philadelphia, Friday, November 12, 1902.

of discharge, under ancient conditions and under present conditions, are briefly given.

The above features—geographic, topographic and hydrographic—are illustrated by colored charts. The more important ports on the great rivers—the Paraná and Uruguay—are mentioned, and some interesting features in reference to the velocity of currents, volumes of discharge, etc., are stated. The present and proposed depths in the two rivers and the commercial features are briefly given. The great Rio de la Plata is specially treated.

After giving the hydraulic conditions of Argentine, there is a brief description and illustrations of the Andes, and the effect of the mountainous condition of the country upon civilization is briefly described.

Having reviewed the physical conditions, a résumé of the history of Argentine is given, including a brief account of the aborigines in this and other parts of South America, with a very brief review of American ethnology. The struggles of the Colonies of Spain to become independent are described, and the influence exerted by the United States during the conflict. The three great heroes of American independence — Washington, Bolivar and San Martin —are compared, and the campaigns and patriotism of the great hero of Argentine, General San Martin, are treated at some length.

Following the history of Argentine, the present Argentine is described—its area, its climate, its productions, and, generally, its agricultural, industrial and commercial features; its telephones, telegraphs, railways, the cable lines which reach it, and, in fact, all conditions of interest.

Following the general description of Argentine is a description of the city of Buenos Ayres, its streets, buildings, water and sewerage works, its extensive port-works, and many details of interest. All of which are illustrated by lantern slides.

Following the general characteristics of the country and city of Buenos Ayres, there is given a brief résumé of the ocean commerce, which has done so much since the discovery of the country in developing its resources. Several important projects for giving additional facilities, both at Buenos Ayres and elsewhere, are described and illustrated.

During the descriptions above stated, there are given comparisons with other cities of the world, including those of the United States, as to population, mortality, growth and other features.

The National Government has recently completed a very important dry dock at one of the more southerly ports of the country, and this is described and illustrated.

The lecture closes by some lantern slides of interesting features of the city of Buenos Ayres, and a brief statement of the reasons which have prompted the lecturer to give this lecture in the United States.

The lecture will be published in full later on. W. H. W.

GAS-ENGINE RESEARCH IN GERMANY.

The Institution of Civil Engineers publishes the following abstract of a report by Eugene Meyer issued in the *Zeitschrift des Vereines deutscher Ingenieure:*

This is the first installment of the results of experiments of gas-engines carried out at the Institute for Technical Physics at the George Augustus University in Göttingen. The engine employed for the research work is a 10 horse-power Deutz motor. Both lighting and power-gas are to be used. A description is given of the engine, power gas plant and the apparatus to be used for measuring the gas, cooling water etc., and the degree of accuracy to be expected with the measurements.

The first questions investigated were concerning the effects of varying amounts of piston lubrication and the temperatures of the cylinder walls. The lubrication was begun with one drop every 40 seconds, for which the mechanical efficiency was 0·706, and the amount of gas used per brake horse-power per hour 823 liters (29 cubic feet), and per indicated horse-power per hour 582 liters (20½ cubic feet). The lubrication was gradually increased until the oil was running in almost a continuous stream. The mechanical efficiency had risen to 0·79, the gas used per brake horse-power per hour had fallen to 648 liters (23·2 cubic feet), and per indicated horse-power per hour to 512 liters (18·3 cubic feet). The load on the engine was practically the same throughout.

The great decrease in the amount of gas used as the supply of lubricant was increased is accounted for by Meyer on the supposition that some of the oil was vaporized in the cylinder and burned along with the gas. More elaborate experiments were made with the same result. In further experiments the temperature of the cylinder-walls was varied from 16° C. to 70° C., while the oil supply was very liberal. In both cases the heat value of the gas supplied was 2412 W.E. (9648 B.T.U.) per indicated horse-power per hour. From this it seems possible that even at comparatively low temperatures lubricating oil may be burned and contribute to the work done on the piston. The accuracy obtainable with the ordinary indicators was specially investigated, and also the methods of calibrating the springs. The temperature of an indicator may of course vary, and it was found in one case that the scale of the spring altered by 4 per cent. when the temperature was changed from ordinary room temperature to about 90° C. The dynamical theory of the indicator is applied to a few actual cases, and a graphic method is given by which the use of a Fourier series to represent the relation between pressure and time is avoided. The inertia of the parts is found to have little effect. Friction and inaccuracy of fitting in the indicator motion are the most important factors in distorting diagrams from their true shape. The indicated power of a gas-engine cannot be determined with perfect exactness, and, while in many cases an accuracy of 1 per cent. may be obtained, in others the errors may be as much as 2 or 3 per cent.

Book Notices.

The Mineral Industry, its statistics, technology of, and trade with the United States and other countries to the end of 1901. Founded by the late Rich'd. P. Rothwell. Edited by Joseph Strouthers, Ph.D. Vol. x. supplementary volumes i to ix. New York and London: *The Engineering and Mining Journal* (Inc.). 1902. Large 8vo, xxx + 982 pp. (Price, $5 in the United States; $7 for foreign countries in the postal union.)

The annual volume of "The Mineral Industry," of which the tenth has lately issued from the press, is so useful a compendium of the progress of the mining and metallurgical arts that it has come to be almost indispensable to those having to do with them professionally or otherwise.

The gathering of the vast amount of facts and figures contained in these year-books by experts conversant with each special branch of the subject, must commend itself to the reader as the only satisfactory method of obtaining data that can be relied upon to be approximately accurate.

The work reflects much credit upon the industry and ability of its editor and his collaborators. W.

Cattle-Feeding with sugar-beets, molasses and sugar-beet residuum. By Lewis S. Ware. Illustrated. Large 8vo, xxiii, + 389 pp. Philadelphia Book Company, 15 South Ninth Street, 1902. (Price, $2.50 net.)

The author is widely known as one of the most persistent pioneers in this country in advocating the domestication of the beet-sugar industry. The present work treats of one of the numerous collateral industries associated with its succcessful development, and deals more especially with the important economic sale which the utilization of certain residual products of the beet-sugar manufacture is made to play in European countries, where the sugar-beet residuum, pulp and molasses are used most successfully for cattle-feeding.

The subject is elaborately treated, and the author's conclusions are supported by an impressive statement of facts and figures. The work should prove of much value to all agriculturists who have the intelligence to know the value of applying scientific methods in their practice.

The book is elaborately indexed. W.

Franklin Institute.

[*Proceedings of the Stated Meeting held Wednesday, December 17, 1902.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 17, 1902.

President JOHN BIRKINBINE in the chair.

Present, 260 members and visitors.

Admitted to membership since last month, 12.

The following nominations were made for officers, managers and committeemen, to be voted for at the annual election to be held on the day of the annual meeting, Wednesday, January 21, 1903, viz.:

For President	(to serve one year)	JOHN BIRKINBINE.
" *Vice-President*	(" three years)	THEO. D. RAND.
" *Secretary*	(" one year)	WM. H. WAHL.
" *Treasurer*	(" ")	SAMUEL SARTAIN.
" *Auditor*	(" three years)	W. O. GRIGGS.

For *Managers* (to serve three years).

CYRUS BORGNER,
JAMES CHRISTIE,
F. L. GARRISON,
H. W. JAYNE,
JARWOOD LUKENS,
LAWRENCE T. PAUL,
HORACE PETTIT,
OTTO C. WOLF.

(To serve for two years.)

CHARLES LONGSTRETH,
WALTON CLARK,
LOUIS E. LEVY.

(To serve for one year.)

WALTER WOOD.

For *Members of the Committee on Science and the Arts* (to serve three years).

H. F. COLVIN,
THOMAS P. CONARD,
GEO. S. CULLEN,
CHARLES DAY,
ARTHUR FALKENAU,
J. M. HARTMAN,
C. C. HEYL,
H. R. HEYL,
GEO. A. HOADLEY,
H. F. KELLER,
LOUIS E. LEVY,
TINIUS OLSEN,
LUCIEN E. PICOLET,
CHAS. E. RONALDSON,
CLAYTON W. PIKE,
SAMUEL P. SADTLER,
HENRY LEFFMANN,
W. N. JENNINGS,
ERNEST M. WHITE,
RICH'D L. HUMPHREY.

(To serve for two years.)

KERN DODGE,
E. GOLDSMITH,
WERNER KAUFFMANN,
JESSE PAWLING, JR.,
FRANK ROSELLE.

(To serve for one year.)

ROBERT H. BRADBURY,
WM. O. GRIGGS,
J. W. REDPATH,
CHAS. A. RUTTER,
URBANE C. WANNER.

Mr. Chas. M. Taylor, Jr., gave an account of his invention of an improved and simplified method of making butter by what he termed the absorption process, and exhibited the process in operation and specimens of the product.

Dr. J. Merritt Matthews supplemented Mr. Taylor by some explanatory remarks on the scientific features of the process.

Prof. Eugene C. Foster followed with a communication describing an improved process of producing oxygen on the commercial scale from liquid air as operated by the Columbia Liquid Air Company, of Washington. D. C. The speaker illustrated the operation of the process experimentally.

On motion, both communications were referred to the Committee on Science and the Arts. Adjourned.

WM. H. WAHL, *Secretary.*

[*Abstract of proceedings of the stated meeting held Wednesday, September 17, 1902.*]

DISCUSSION:—THE SUPPRESSION OF THE LOCAL SMOKE NUISANCE.

Remarks of MR. JOHN M. HARTMAN.

Can the smoke nuisance be abolished? No.

Can it be abated? Yes.

To what extent? Say, 80 per cent.

Bituminous or soft coal has come to stay. With each successive strike in the anthracite districts its use has become more general; and the manufacturer finding it better adapted to his use, and cheaper, will continue the use of it. Under these circumstances, it now becomes the duty of the city government to establish laws regulating its use, as has been found necessary in Pittsburg, Chicago, St. Louis, Cleveland and elsewhere.

It is the proclivity of Americans to love walking on the edge of a precipice. In running their boilers they work them up to the full extent, often beyond it, with an occasional explosion. In thus running we have a smoky chimney when using soft coal, as the volatile matter evolved from it passes off largely unconsumed. If the boiler owners would add extra coking surfaces to their boilers, retaining their grates, they could consume the gas (and their boiler also if they were careless). To this want of boiler capacity, add bad firing, with poor draught, and we have stated the case of the present smoke nuisance in Philadelphia. Metallurgical furnaces, of course, contribute their quota.

This extra coking surface will help to do more than normal work with a boiler, without smoke, though at the expense of the coal-bin. The first operation in burning soft coal is the driving off the volatile hydrocarbons. These gases and vapors must be burned quickly so as to utilize their heating effect at once, and the remaining part of the coal must be promptly changed into coke. The second operation is to burn the coke, the heat from which in its turn heats the gases and assists in developing their full heating power. One pound of these gases develops more heat than a pound of anthracite. The burning of these gases increases the intensity of the heat in the furnace and perfect combustion ensues, no smoke being visible at the chimney-top. The first operation, therefore, is a coking process, and should be kept separate from the second operation, which is a burning process. No fresh coal should be placed on the burning coals of the firing surface, as it lowers its temperature and causes smoke.

There are three types of furnaces that cause the smoke nuisance:

First, stationary boilers.

Second, locomotive, marine and portable boilers.

Third, metallurgical furnaces.

STATIONARY BOILERS.—All our stationary boilers are set with grates close to the boilers, as anthracite coal burns with a short flame and no smoke. Bituminous coal burns with a long flame, requiring the grate to be placed much farther from the boiler in order to give the gases time to burn before reaching the cold surface of the boiler; otherwise the gases are chilled and are not completely burned, giving a smoky chimney-top.

The first question that suggests itself to the practical mind is, what can be done quickly and cheaply to burn soft coal under such boilers with less smoke? The answer is: "Lower the grate-bars and put openings in the side-walls to admit air over the surface of the fire." The admission of the air should be through a valve controlled by the fireman. On throwing coal over the fire he opens the valve wide, and closes it as soon as the gas is burned off. Otherwise he lets in air when it is not wanted, and a chilling effect is produced, causing a waste of fuel. Some smoke, but not much, will appear at the chimney when fresh coal is thrown on the fire or when the fireman rakes the fire, but it will not be above the No. 2 scale of Ringelman.

If owners and users of boiler furnaces adapted for anthracite are willing to expend a little more money, the following method will enable them to obtain practically smokeless combustion with soft coal.

Retain the usual firing surface or grate, and removing the fire front from the underside of the boiler down to the top of the lowered grate bars or firing surface, then place at the end of it an inclined surface the full height and width of the furnace and allow the coal to slide down this broad surface. The coal is thus exposed to the radiant heat of the furnace, which drives off the gas constantly and before it reaches the firing surface. This prevents cold fuel from coming in contact with the firing surface to lower its temperature and interfere with the proper burning of the gas. As the firing surface needs replenishing from time to time, the fireman should push the coked coal from the bottom of the incline over the firing surface, keeping the bed uniform in thickness and the fire hot. As the coked coal is pushed forward the coal above slides down the incline to fill up the vacancy. A large hopper should be placed above the incline to feed the coal to the incline by gravity as fast as it is used. Pushing back the furnace top to get the incline enlarges the furnace and allows more time to consume the gas.

The factor of time in the furnace to burn the gas properly is important; the more time allowed, the better the combustion. The widening of the incline allows a thin sheet of coal to slide down, giving the radiant furnace heat a better chance to penetrate through it and drive off the gas. Some mechanical stokers have the incline but do not provide a large grate surface at the bottom of the incline.

These suggestions apply only to the present hand-fired furnaces as a cheap means of helping the smoke nuisance.

LOCOMOTIVES, PORTABLE AND STEAMER BOILERS.—If one observes a locomotive being fired, he will usually notice that after the coal is thrown on the fire a thick bronze-black smoke appears at the top of the stack, which in a few minutes clears up. The coal soon cokes together, which interferes with the draught, the fireman with his scraper breaks up the coked crust, causing a thick black smoke. There had been too much coal thrown on the fire at one time and the heat coked the surface of the coal before the gas was expelled from the interior of the coal. The sudden change from the cold air to the hot fire has done this. If the coal had been gradually heated up, nearly all the gas would have escaped before the final coking and the high heat of the furnace would have been maintained.

Why do some locomotive firemen go along with little smoke, while others leave a heavy black cloud a mile or two long? If one can do it, why not

all? The first man is firing with his brains, using coal little and often, doing his work well. The second man is firing with his muscle; the results we know and feel. He does not work up all the nice points of his duty and does his work badly. Large locomotive boilers with only one fire-door, not large at that, place the fireman at a great disadvantage to keep an even fire. He is compelled to heap the coal in places, and after the smoke passes off enough to see the bed of fire, he must take the scraper and try to level off the coke. This brings into play the hidden surfaces of the coal not yet having lost their gas, and smoke appears at once at the chimney-top.

The inclined coking surface can be applied to any boiler by an intelligent mechanic; it is simply an enlargement of the patent of James Watt in 1785, called coking on the dead plate. By making this incline in two parts, hinged at each side, it is quickly opened and the whole furnace readily got at for repairs or examination. Other arrangements can be made with a little mechanical skill, but simplicity and durability must be adhered to.

The New York Central Railroad has adopted a system of gas-burning after testing it under adverse circumstances, in which they found a saving of 12 per cent. of fuel, the locomotive doing that much more work. The smoke was trifling and fell below No. 2 scale.

A fire-brick arch suspended above the grate surface of locomotive furnaces has been of great help in burning the gas. It has had more general use than any other improvement.

At present all locomotives are forced beyond their capacity owing to the great rush in freight and travel and the shortage of locomotives.

METALLURGICAL FURNACES.—Under this head come coal puddling and heating furnaces for iron, gas open-hearth, gas-heating furnaces and forges.

In the boiler furnace the sole object is to burn the fuel to carbonic acid and get the highest heat out of it. In metallurgical furnaces fired with coal the gas can be burned to its highest heat until the metal begins to soften, when the gas must be burned to one volume of carbonic acid and one volume of carbonic oxide, called a neutral flame, to prevent the metal being burned or oxidized. During the time of the neutral flame smoke shows at the chimney-top. Carelessness at this juncture will burn the iron. If this gas is burned with plenty of air after it leaves the neck of the puddling furnace, it can be used to generate steam and leave no smoke escape worthy of mention. Arrangements for this purpose have been perfected and when properly handled are working well at large establishments in this city. Furnaces fired with gas have regenerators to heat the gas and the air, thereby obtaining higher heat and greater economy of fuel. These furnaces will never smoke unless they are driven beyond their capacity or under certain conditions, when to save their metal they use an excess of gas, causing smoke to appear at the chimney-top for a short time.

Metallurgical furnaces should have high chimneys, and their escaping gas should not show higher than No. 3 of the smoke scale at short intervals. Escaping gas from the gas furnaces goes off at about 600°, which sends it well up into the air through a high chimney and is dissipated before it can seriously annoy the public.

Every establishment visited by the speaker had one common remark to make, viz.: "So much depends on the fireman attending to his duties prop-

erly." No matter whether hand-firing or mechanical stoker is used, the same complaint is made. This shows the necessity of having a corps of firemen who, after trial and passing a satisfactory examination, should be licensed by the city. We license engineers; why not license the men who hold a position far more dangerous than the engineer? A few minutes of low water and an explosion may take place which may destroy life and wreck the premises. They should be men of good qualifications and properly protected by rules that would be just for all. They should be held responsible for excessive smoke and not annoy the owner with things the fireman is delegated to do by the city. Firemen using anthracite can fix up their fires and rest twenty minutes to a half hour before looking at their fires again. With soft coal attention is required every five minutes or less if it is required to burn the coal economically and without smoke. It is constant attention that is required, and to shirk this labor the fireman lets his fire burn down low, then shovels the furnace full of coal, causing the black-smoke nuisance, and a waste of fuel.

Locomotive firemen find it easier to sit in the cab and play with the locomotive bell than to be steadily firing and get good results. The engineer is on constant duty from the time the train starts to the end of his trip; why not the fireman also?

Mechanical stokers are used in many large establishments with good results and little smoke. In small establishments they have not come into use for lack of room and cost. They should be used where practicable, but even with mechanical stokers, it is found that an experienced man must run them.

The "Committee on the Smoke Nuisance," appointed by the Councils of Philadelphia, want to recommend the use of just laws for the benefit of the city, and to cause as little trouble and expense to citizens as possible. They desire to meet parties interested and will give them a careful, courteous hearing.

Committee on Science and the Arts.

(*Abstract of proceedings of the stated meeting held Wednesday, December 3, 1902.*)

MR. THOS. P. CONARD in the chair.

The following reports were adopted:

(No. 2206.) *Turrett Lathe.*—Julius Wilhelm v. Pillter, Leipzig, Germany.

ABSTRACT.—A supplementary report introducing some further information respecting the comparative merits of the v. Pillter machine and American lathes of the same class. The Edward Longstreth Medal of Merit is awarded to the inventor. [*Sub-Committee.*—Hugo Bilgram, Chairman; Arthur Falkenau, J. Logan Fitts.]

(No. 2235.) *Hydraulic Ram.*—Chas. C. Wentworth, Roanoke, Va.

ABSTRACT.—The invention is not a patented one. The features of novelty, for which particular merit is claimed, consist in the arrangement of pipe and

check-valves for maintaining the supply of air in the air-chamber, and the combination with the waste-valve of a spring buffer to prevent the shock of closing. The details would be unintelligible without the aid of illustrations.

The report awards the Edward Longstreth Medal of Merit to applicant for "the ingenuity displayed in the analysis of the problem, the efficient and simple manner of reducing shock in the waste-valve, and the careful attention to the details of construction and installation. [*Sub-Committee.*—Lucien E. Picolet, Chairman; Chas. E. Ronaldson.]

(No. 2242.) *Electrolytic Method of Making Caustic Alkali and Bleaching Powder.*—Chas. E. Acker, Niagara Falls, N. Y.

This report is reserved for publication in full. The award of the Elliott-Cresson Medal is made to the inventor. [*Sub-Committee.*—Jos. W. Richards, Chairman; Chas. J. Reed, Sam'l P. Sadtler.]

(No. 2251.) *Bridging-Bell for Telephones.*—John J. Carty, New York.

ABSTRACT.—This invention is the subject of letters-patent No. 449,106, March 31, 1891, granted to applicant, and describes a multiple-circuit arrangement for telephone party lines, including at each station a permanent bridge in which is seated a bell magnet with a high coefficient of self-induction and of marked impedance. There are also two other bridges, normally open, and closed only when the station is in use. The telephone circuit, normally open, is closed in multiple arc with its own bell magnet, and, of course, with all others in the line, when in use. The generator-call circuit, normally open when used, forms a second bridge or cross connection between the wires in parallel circuit with the bridge circuit of its own bell and those of all others in the line. In operation, the tendency of the call-circuit to short-circuit is counteracted by using a bell magnet of high self-induction and impedance.

This not only prevents short-circuiting, but also effects more even current distribution through the bell magnets of the entire system. By means of the numerous windings of the bell magnets, the small fraction of the call-current passing exerts a marked magnifying effect on the cores and a spirited working of the call-signal.

The investigators find, after an examination of the prior state of the art, that "Mr. Carty's work consisted in adapting the bridging-bell to party lines by increasing the resistance of the bell-circuit to make it opaque to the transmission of voice-currents. * * * and that in the adaptation of well-known electrical engineering principles to a particular and difficult branch of telephony, it shows professional skill of high order." Since the use of this method has contributed largely to the expansion of party-line telephony, the award of the Edward Longstreth Medal of Merit is made to the inventor. [*Sub-Committee.*—L. F. Rondinella, Chairman; E. A. Scott.]

The following reports passed first reading:

(No. 2229.) *Hydrocarbon Burner.*—C. Francis Jenkins, Washington, D. C.

(No. 2248.) *Photo-polychrome Printing Process.*—Henri J. Burger, Zürich, Switzerland.

(No. 2265.) *Window Structure.*—Theo. H. Schmitz, Philadelphia.

(An advisory report.)

JOURNAL

OF THE

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OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CLV, No. 2. 78TH YEAR. FEBRUARY, 1903

ELECTRICAL SECTION.

Stated Meeting, held March 20, 1902.

Electrical Measuring Instruments.

BY CARYL D. HASKINS.

In selecting for the title of my paper so vague a term as "Electrical Measuring Instruments," I am quite aware that almost anything might be expected of me. Webster, I believe, defines the term "instrument" as a tool or implement. The selection of the word instrument, with its very vague literal meaning, for use in connection with a very concrete and definite class of electrical apparatus, is regrettable, but doubtless now beyond correction.

In electrical engineering practice the term "instrument" has come to mean very definitely all of that large group of devices which serve to indicate at any time the definite value in the desired unit of some electrical phenomenon. In short, the generic term "instrument" has been narrowed almost to a specific term, from sheer necessity resulting

from the paucity of our language as applied to our own particular art. In 1890 the term "electrical instrument" was indiscriminately used as applicable to an integrating meter, a curve-drawing meter, an indicating instrument, and even a magneto. To-day common commercial usage, which is always impatient of long titles for common things, has so narrowed the practical application of the term "instrument" as to almost literally confine it to those devices which indicate with a needle or the equivalent the value of what is under measurement. In the laboratory and among pure scientists the term has not been reduced to this specific meaning, and is still used and probably always will be used in its more generic sense, and as applicable to devices which the practical central station electrical engineer would scarcely recognize as coming within the scope of the term, even if broadly construed.

My paper to-night is devoted to that class of instruments which we may term *working instruments;* that is, those which are used in daily practice, and not so much for testing purposes as for purposes of frequent observation and indication of conditions. Such instruments, in short, as are used upon switchboards, or are carried from place to place for the purpose of making a large number of daily observations.

It is not my purpose to deal with the primary standards of measurement, even remotely. Nor do I intend to deal with the secondary or bench standards which are used in comparing, checking and calibrating the working instruments.

There are two natural divisions of the electro-dynamic art, which separate instruments into two general classes—those suitable for use upon continuous current circuits only, and those for use upon alternating currents, this latter class being quite commonly capable of use upon continuous current also, with at least fair accuracy.

With instruments of position, which are by far the most important group commercially, and are used by thousands where portable instruments are used by hundreds, the design is of necessity governed by a number of essential qualities necessary to make an instrument practical and serviceable for constant use.

Passing over accuracy as an obvious necessity, we find that the quality of at least next importance is that of *permanence.* This means that the successful instrument must consist of elements unlikely to change either temporarily, on account of outside influence, or permanently, because of internal derangement.

This characteristic naturally implies indifference to external influences, as, for instance, the effects of stray fields, or of temperature.

For most applications, instruments of position must be highly "dead beat." This is an unfortunate term and I dislike to use it. It appears, however, to have no synonym. An instrument, however accurate, having a needle which vibrates and swings under fluctuating loads so constantly as to practically never come to rest is well-nigh valueless for most practical applications. It is, therefore, important that instruments for all such applications should be so designed as to cause the needle to come quickly and definitely to rest, and this must be accomplished without resorting to means likely to impair its sensibility.

For example, an instrument may be made to come quickly to rest by merely increasing the friction of the moving parts, but obviously such a means of achieving the desired purpose is highly detrimental, unless indeed the friction be applied only at will and intermittently.

On the other hand, the use of a damping structure, dependent upon the generation of foucault currents in a moving disc or sector, passing across the field of a magnet, is well-nigh ideal, involving as it does substantially no increase of friction and yet effectively checking vibration.

Finally, in instruments of position, the length, legibility and distribution of the scale is of great importance.

There is a considerable variance of opinion among electrical engineers as to the preferable scale distribution. An evenly divided scale, showing the same linear deflection of the needle for any given value throughout the entire scale length, has been quite commonly preferred, and this was especially true in the earlier state of the art.

On the other hand, to-day, preference naturally and I

think logically trends towards a maximum scale length through that portion of the scale likely to be most commonly used.

To illustrate: an ammeter used in measuring the current from a single generator of say 500 amperes rated capacity is seldom referred to to ascertain definite values below 250 amperes. Hence, it is the area between 250 amperes and

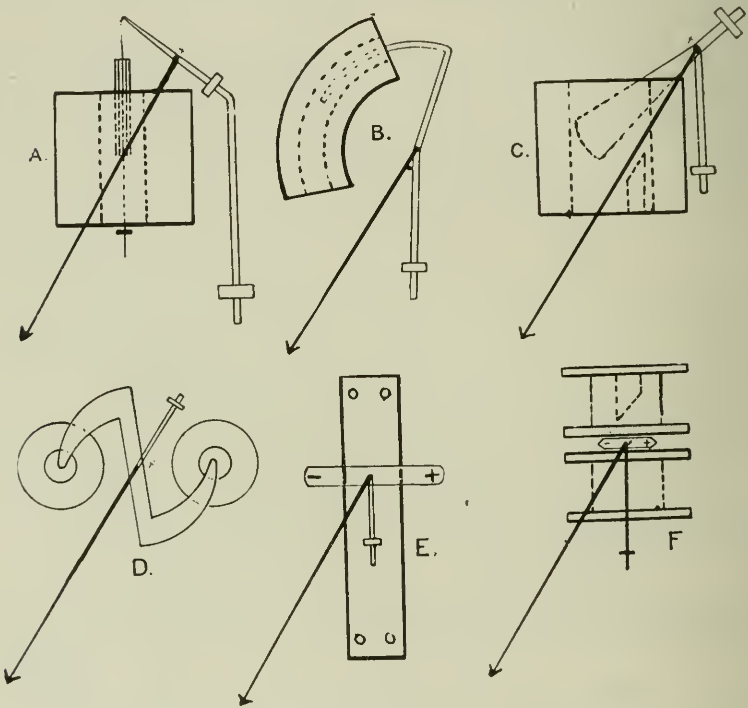


PLATE I.

full scale that is of the greatest value, and this area should be large in relation to the scale area below the half-load value of the machine. It is true, that the lower portion of the scale may be required at times, but close measurements at these low points are rarely needed and narrow divisions imply nothing undesirable.

Having outlined a few of the more important requirements for instruments of position, I propose to lay before

you some of the elementary principles which have been resorted to in the art of instrument design.

Before outlining these various principles I wish to remind you that the designer, surrounded as he is by the most sordid of commercial considerations, has generally conspicuously before him not only the essential characteristics which I have mentioned, but also the more irksome ones, which prescribe that the product of his ingenuity must be cheap, easy of manufacture and capable of shipment for long distances by the common means of transportation, with a fair prospect of arriving at its destination in a workable condition.

The various principles which have been resorted to in designing instruments of the class with which I am dealing may be grouped as follows:

(1) *Modifications of the mariner's compass*, or simple galvanometers, consisting of a polarized movable element under the influence of a coil or coils, carrying the current to be measured. This is the earliest group. Plate I, *Fig. E.*

(2) *Solenoids.*—Dependent upon the pull of a coil or coils on an iron plug or armature acting against gravity, a spring, or other restraining force. Plate I, *Figs. A, B, C, D, F.*

(3) *Magnetic repulsion instruments having iron*, consisting of a movable and a fixed piece of soft iron, both situated in the same field, consisting of a coil or coils carrying the current to be measured. Both pieces of iron being polarized in the same direction tend to repel each other, this force acting, as in all of the instruments in the mechanical group, against some restraining force. Plate II, *Fig. B.*

(4) *Magnetic Vane Instruments.*—Consisting of a vane or armature of soft iron, constituting the moving element, and placed within the influence of a coil or coils carrying the current to be measured. The normal position of the magnetic vane at no load is across the magnetic path created by the current in the coil or coils, the tendency being for the vane to place itself parallel with, or in some cases to surround the field created by, the passage of current through the coil. Plate II, *Figs. A, FF.*

(5) *A fixed and a movable coil or coils*, sometimes with, but

generally without iron — a development of the Siemens dynamometer. The movable coil tends to place itself either at right angles to, or in the same plane with, the fixed coil, depending upon the relative direction of current in the two coils. This principle may obviously be modified to provide for one fixed coil repelling and another fixed coil attracting a movable coil. Plate II, *Figs. H, D.*

(6) *A movable coil, with or without iron, situated in the field of a magnet,* the movable coil tending to take a position at

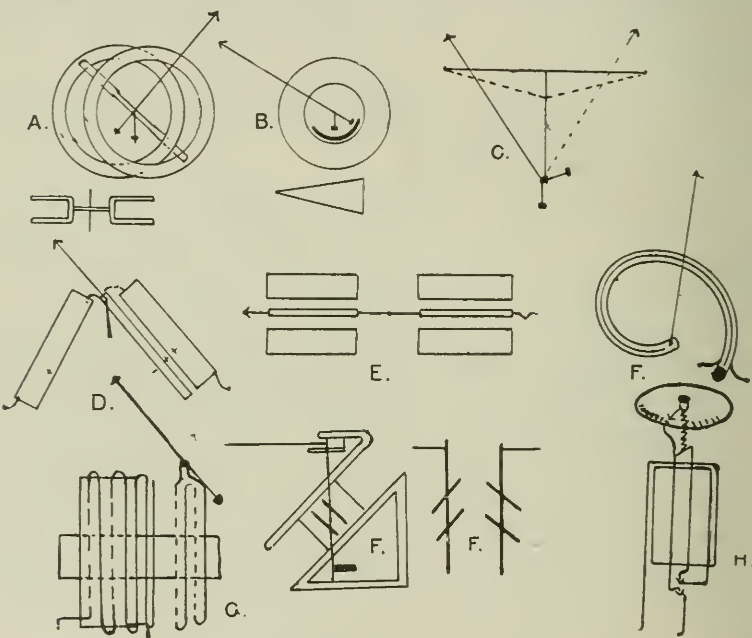


Plate II.

right angles to, or parallel with, the flux of the permanent magnet, depending upon the direction of current in the moving coil — a development of the D'Arsonval galvanometer. Plate III, *Figs. B, C, D, E.*

(7) *A movable coil or conductor,* commonly with a small number of turns and frequently consisting of a disc or sector instead of a coil, constituting a short-circuited secondary in the field of a coil or coils carrying the current to be measured. This device is operative on alternating current

only. The movable short-circuited coil or sector tends to move in relation to the fixed field exerting force in opposition to the restraining force of a spring or gravity. Plate II, *Fig. G.*

These classes (groups 1 to 7 inclusive) constitute what might be termed the Dynamic Group.

It will be noted that of these, four groups (1 to 4 inclusive) consist of instruments having a moving element carrying no current, and are therefore free from conductors. Groups 5, 6 and 7 have moving wire-carrying current, necessitating the introduction of flexible conductors or collectors.

We now come to a series of somewhat indefinite groups, which may be broadly classed as *temperature instruments*, in which the position of the needle or indicator is governed by a change of temperature; in short, *thermometers* applied to electrical measurement by resorting to structures, the temperature of whose governing parts will vary with the current to be measured. There are in this general class the following groups, which unfortunately are less well defined than the genera of the dynamic group:

(8) *A thermometer surrounded by a conductor whose temperature varies with the current*, the scale of the thermometer being graduated to indicate the current causing any given temperature. Such instruments, in common with most of this class, are dependent upon a fixed room temperature, unless a correcting constant or means for mechanical correction be provided. Plate IV, *Fig. E.*

(9) Instruments in which the position of the needle is dependent upon the expansion or contraction of a conductor, due to changes of temperature in that conductor, caused by the current passing through it. Plate II, *Fig. C.* A well-known type of this group is the Cardew voltmeter.

(10) *Thermostats Provided with an Indicating Needle.*—The moving element consists either of a metallic and non-metallic substance, with differential coefficients of expansion, the metallic element carrying the current, or a moving element consisting of two metals of different coefficients of expansion connected in series, and carrying the current; Plate II, *Fig. F;* or a simple thermostat heated by radiation from a fixed coil, the moving element carrying no current.

There is one principle which has been used in electrical instruments which is more commonly seen in pure thermostats. It falls within the next group.

(11) *The development of pressure within a confined space*, due either to the expansion of gas or fluids under temperature-increases, or to the volatilizing of a fluid having a low boiling point. Plate IV, *Figs. C, D.* The generated pressure may either expand a diaphragm forming a portion of the walls of the receptacle retaining the gas or fluid, or may

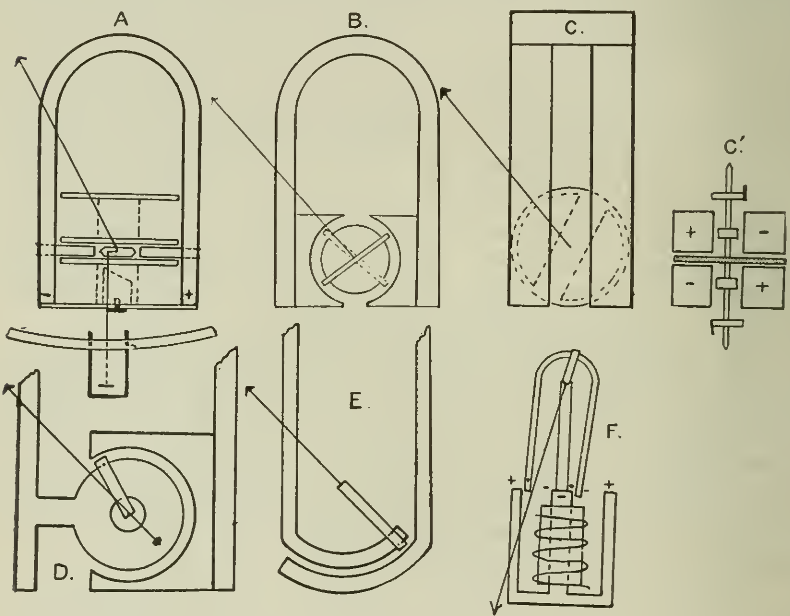


PLATE III.

cause the straightening of a bent tube containing a volatile fluid, or gas, as in a common form of thermostat. In the first form motion is communicated to the needle as in a steam-gage or an aneroid barometer. In the second form by the direct attachment of the needle to the bent tube.

There are other instruments falling within the thermal class, which hardly come within the scope of the definitions I have cited. They are unimportant and are intentionally omitted.

(12) *Electrostatic Instruments.*—These comprise a single family and genus. They consist of *practical applications of the electrometer* and several practical forms. Two or more plates are symmetrically arranged in two, or in some cases three groups. One group is attached to one pole of the system under measurement, and the second to the other pole. The moving element consists of a light metallic vane having *capacity* large in relation to its mass. The tendency of the moving vane is to place itself with its greatest length parallel to the shortest path between the plus and minus fixed plates. Another form has one or more fixed plates attached to one pole of the system to be measured, and a movable vane attached to the other pole. The tendency in such a structure is for the movable vane to place itself parallel with the shortest path between the fixed plate or plates and the point of attachment of the movable plate or plates.

Modifications of structures of this kind are used for the detection of grounds. When so used, three or more groups of plates are provided, the movable vane sometimes constituting one, whilst one group is connected to ground. With this arrangement a ground renders the permanently grounded plate and the newly grounded plate a common element, the movable element adjusting itself in position accordingly.

Instruments of this class are largely used for the measurement of very high potentials where the conducting of current through a coil, moving or otherwise, would be attended either with grave practical difficulties or with material physical danger to the structure or human life, or with an unnecessary expenditure of energy. Plate IV, *Figs. I, J.*

We now come to a class of instruments in which the actuating force of the needle is derived from an independent source, and its application to the moving element is only governed, either in volume or in period, by the current to be measured. We have in this class two general groups:

(13) *A source of air or fluid pressure, controlled in intensity by a valve;* for example, a reducing valve electrically controlled, a source of air or fluid pressure, and a pressure gage. Plate IV, *Fig. G.*

(14) *A Clock or the Equivalent Directly Connected to a Needle.*— In such a structure the clock is started by the current and drives the needle forward over the scale until the torque of a spring connected to the hand balances the coercive force of the measuring coil, at which point the relay contact is broken, causing the clock to stop with its needle upon the value reached. This device is a modification of the balance, and is practically a weighing machine. Unless still further

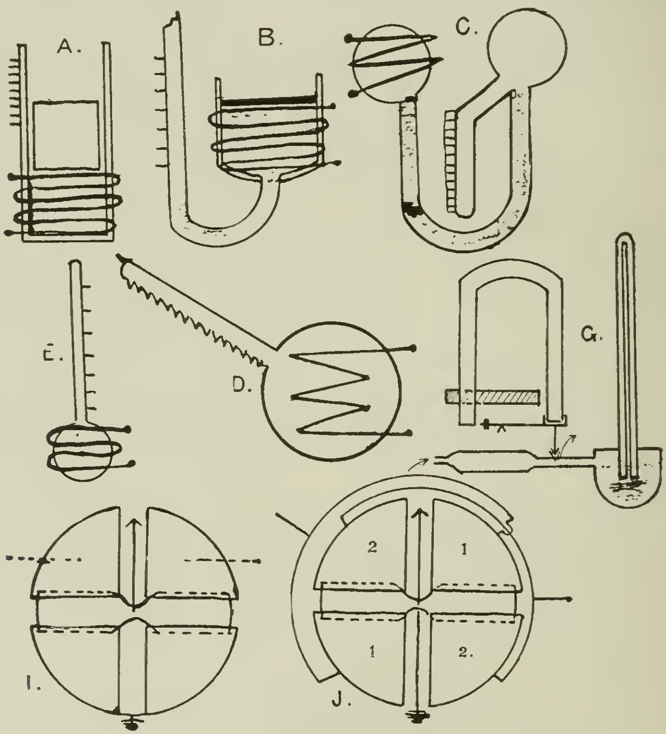


PLATE IV.

modified the needle remains upon the highest reading reached during use.

We now come to a class of instruments really used as *working instruments of position*, but very generally used for secondary or bench standards. These are balances, structurally incapable of indicating the desired measurement without manual manipulation. They are two general classes.

(15) Instruments in which a definite torque is produced by resorting to any of the structures heretofore described (but generally to a fixed and movable coil or coils). This torque is manually balanced by the winding up of a spring, as in Siemens dynamometer, or by the manual adjustment of a counterweight, as in the Kelvin balance—the position of the needle attached to the spring manually wound, or the position of the weight manually adjusted being read. Such readings may be direct, but for convenience are more commonly arbitrary, and are multiplied by a known constant. Plate II, *Figs. H, E.*

(16) Instruments designed to be brought to zero used in conjunction with a Wheatstone bridge.

It is possible that in thus classifying the means which have been resorted to in the effort to produce indicating instruments, I may have treated my subject in too elementary a manner, and my excuse is, that I know of no paper, book, or essay, in which full classification has heretofore been attempted.

We now come to some mechanical considerations. First in importance (because most essential) is the means of communicating the motion of a moving element to a second element which shall move across the scale. Commonly this is achieved by the direct attachment of a needle to the moving element proper. This, however, is not the unvarying method. In the solenoid group, for example, we find a type of instrument in which the moving element (a plug of iron) floats on mercury within a glass receptacle, the iron being drawn down into the mercury by the current in the fixed coils, and the level of the displaced mercury in relation to its normal level being read. Plate IV, *Fig. A.* Similarly we find the thermometer stem not uncommonly used, the level of the fluid within the stem being governed by the pressure upon a diaphragm, or by temperature, the reading being taken as in the thermometer. Plate IV, *Fig. B.*

Sometimes the Scale is Moved in Relation to a Fixed Needle.—Deviations from the simple plan of attaching the needle direct to the moving element have commonly been resorted to in the effort to increase the angular movement of the

needle in relation to the angular movement of the moving element. Numerous mechanical multipliers have been used for this purpose, such as direct "gearing up," just as in a bicycle. Such mechanical modifications are of doubtful advisability. The coercive force of an instrument must always be relatively very small, and the introduction of friction, inseparable from any mechanical multiplier, is highly undesirable in any device where a small coercive force must be communicated with precision to an indicating element.

It is not my desire to condemn mechanical multipliers, but rather to call attention to the inherent difficulties incident to their use, introducing as they do a variable factor, difficult to so construct and adjust as to remain fixed in value.

It is, of course, highly desirable to secure the greatest possible angular deflection of the needle that can be achieved without introducing other detrimental characteristics. There are, however, other and perhaps better means of accomplishing this than by resorting to mechanical multipliers. An iron vane or a moving coil may be mounted eccentrically to a fixed coil in such a manner that the moving vane or coil in passing from the minimum to the maximum position in relation to the fixed coil must revolve its pivot or shaft through a large angle in relation to its plane. Plate II, *Fig. FF.*

It is proper that we should now consider the question of a restraining force.

Substantially all instruments within the groups with which I am dealing consist of a moving element, which, under any given coercive force, changes its position until the coercive force applied to it balances or equals the applied restraining force. This restraining force may be applied in several ways. Thus:

A spring may be used, as the hairspring of a watch, placed under torsion by the progress of the moving element.

The force of gravity may be utilized by the lifting of a weight, equivalent and in some respects superior to the spring. Plate I, *Figs. A, B, C, E, F.*

A magnetic field may be provided with an iron armature attached to the moving element, and so situated as to occupy the shortest magnetic path when the instrument is at zero, this restraining armature being dragged for a greater or less distance out of the restraining field by the coercive force of the instrument. Plate III, *Fig. A.*

These three methods of securing a suitable restraining force cover substantially all of the methods used in the construction of instruments, with the exception of thermal instruments, most of which seek their zero position because it is their normal static condition.

After the instrument-designer has selected the restraining method most suitable to the device under consideration, he must (if the instrument be of the class requiring dead-beat qualities) next consider how the vibration of the needle is to be checked without detriment to precision. This has been accomplished in numerous ways, all more or less effective.

(1) By application of friction. This method of damping is to be found, without intent on the part of the manufacturer, in all instruments having bad bearings.

It might be well to call attention at this point to the fact that the heavier the moving element the greater the friction, other things being equal; and also the greater the inertia and the greater the storage of energy in the moving mass. Hence, the heavy moving element is more difficult to make satisfactorily dead-beat than the lighter moving element.

Friction for the purpose of damping has been purposely applied in numerous instances, but generally only in the form of a brake, to be used at the discretion of the user.

(2) By the dash pot, which is a vane or piston moving through fluid, or a tight-fitting piston in an air cylinder like a door check.

(3) By a hollow cylinder, or more usually by a disc-shaped cylinder, partly filled with a somewhat viscuous fluid such as glycerine.

(4) By a simple disc-shaped cylinder containing one or more small spheres or balls acting in a manner almost

exactly similar to the viscous fluid, but without the objectionable tendency of the viscous fluid to adhere to the sides of the cylinder above normal level, thus changing the balance of the moving element.

(5) By means of air vanes moving in a more or less confined space. These are highly effective in checking the swing of light-moving systems, since such systems have a higher period vibration and, consequently, during vibration move more rapidly; and since the resistance to motion on the air fan increases as the square of its velocity, it will be seen that such fans can most efficiently be applied in connection with the damping of high speed vibrations.

(6) By the generation of foucault currents, which may generally be regarded as the better means of damping without the introduction of detrimental effects. This class of damping takes two forms:

A fixed metallic body, so placed that the movement of a magnetic body in juxtaposition to it shall generate foucault currents within its mass, as by the enclosing of a compass needle within a copper cylinder, the lines of force projected by the needle cutting the mass of the copper cylinder and generating foucault currents therein. Or, a disc or sector attached to the moving element and moving across a magnetic field, as described earlier in this paper.

The volume or intensity of current to be measured is in ordinary practice frequently so considerable as to make it highly undesirable and indeed practically impossible to bring the actual total current to be measured through the instrument. The cost of bringing the current to the instrument would in a large number of cases be prohibitive, even though other considerations rendered it permissible. This necessitates some ratio device. In connection with current measurements these ratio devices are of two kinds: one applicable to alternating current and the other to direct and sometimes to alternating current. The first of these ratio devices—that applicable to alternating current—is the current transformer, a simple transformer having a primary of extremely low potential, consisting of a small number of turns or even part of a turn, the primary being connected

in series with the line conducting the current to be measured. The secondary of this transformer is of a relatively large number of turns and a higher potential, and is short-circuited through an ammeter whose actual current capacity is small, but the scale of which is calibrated to read the current in the primary of the transformer. It should be understood that the potential of the secondary of the transformer, though referred to as relatively higher than the primary, is itself extremely low. It will be seen that the current in the secondary of the transformer will vary in a direct ratio with the current in the primary through the range of the transformer iron, and therefore the indication of the instrument varies in exact relation to the fluctuation of current in the primary. The introduction of a current transformer, therefore, not only obviates the necessity of conducting heavy leads to and from the instrument, and all that it implies, but also isolates the live portions of the instrument from the actual potential of the system, rendering the instrument harmless.

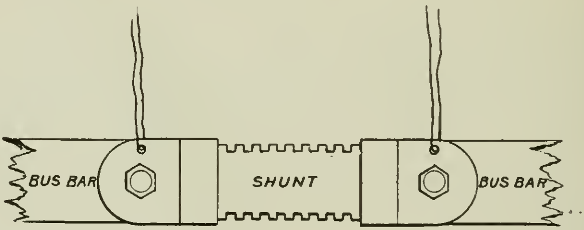
The other ratio device, more commonly used for direct current applications, and sometimes for alternating purposes also, is the shunt. The shunt method briefly consists in measuring the fall of potential around a known resistance. For convenience this known resistance, which must of course be very low for practical reasons, is designed as a separable portion of the conductor and is made from a metal of very low temperature coefficient. The shunt method, it will be noted, achieves the same desired purpose as does the current transformer, save that the live portions of the instrument are in this case electrically connected to the actual system under measurement. This, however, is entirely permissible, since this method is rarely if ever applied to systems of dangerous voltage.

For use in connection with volt-meters on high potential systems a second form of transformer known as potential transformer is very generally used. Like the current transformer this is a ratio device having a primary winding of a large number of turns attached across the system, the potential of which is to be measured, with a secondary winding

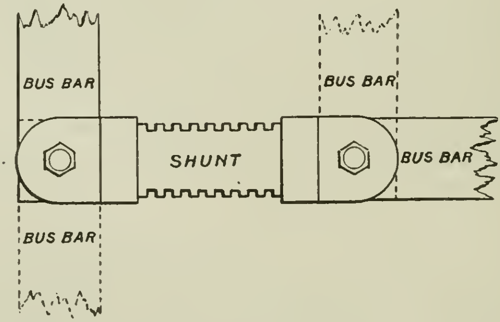
of a relatively low number of turns and impressing a relatively low potential upon the volt-meter to which it is electrically connected. As in the current transformer, the potential of the secondary varies in direct relation to the fluctuations of the primary potential. Volt-meters thus arranged are, however, not commonly calibrated in the potential of the primary, but rather in the secondary potential which prevails throughout the system served. In common with the current transformer the use of the potential transformer not only obviates the necessity of exercising extreme care in the insulation of the leads to and from the volt-meter, but also isolates the live portions of the volt-meter from the higher potential of the system.

Discussion.

Mr. Richard L. Binder inquired as to the relative accuracy of the shunt-type instruments and series-type



This arrangement gave one reading, and



this gave another reading; and on changing bus-bars to the various positions a different reading was recorded each time—about 500 ampères at 110 volts passing.

instruments, stating that in one instance with a shunt-type instrument he had noticed a variation in the readings depending on how the bus-bars were led into the shunt, and requesting information as to what caused this variation. The sketches accompanying will explain what was done at this experiment.

MR. HASKINS: There is no inherent difference in sensitiveness to stray field from bus-bars, etc.; between shunt-type ammeters and series-type ammeters. All indicating instruments which are not conducted on the astatic principle, or which have not some specific means for effectively shielding the moving parts against stray fields, are affected by neighboring bus-bars to some degree. In the case cited the errors undoubtedly resulted from the position of the bus-bar and leads, and were in no way related to the shunt.

MR. CARL HERING: In his interesting paper, Mr. Haskins objected to the term "dead-beat," and regretted that there was no better term in existence. I agree with him that the term is not a very desirable one, owing to its other meanings, although it originated, no doubt, from the fact that it meant that the beats or oscillations of the needle are deadened. He is, however, mistaken in saying that there is no other term, for the term "aperiodic" expresses precisely the same thing. It comes from two words, meaning that the needle then has no period of oscillation; that is, it does not oscillate like a pendulum. It does not mean that the needle is made so light and small that its natural period of oscillation, if free, is negligibly small, but, on the contrary, refers more to relatively large and heavy needles that would have a very decided period of oscillation if free. The word, therefore, does not refer to the natural period of oscillation if it were free, but simply means that, as used, the needle makes no or very few oscillations. The term is used in the German and French languages in a sense precisely the same as the one in which we use the objectionable term "dead-beat." I have been trying for years to help to introduce the word into this country, but with only moderate success. It would be well if experts became more familiar with it, and used it in the place of "dead-beat."

MR. HASKINS: I welcome Mr. Hering's suggestion of the adoption of the term "aperiodic" instead of "dead-beat" as a timely and appropriate one. I apprehend but two difficulties in the introduction of this term in American and English practice: (1) The fact that the term "dead-beat" has become universal, and (2) a certain literal difference of meaning, which in European practice has been entirely offset by custom. I share with Mr. Hering the hope that this word may be substituted in American practice for the term "dead-beat."

PROF. ARTHUR J. ROWLAND: We rarely have an opportunity to listen to one who has had so much to do with the development of modern electrical instruments as Mr. Haskins, or to ask him questions. When, therefore, I found that Mr. Haskins was going to present the paper we have been listening to before the Electrical Section, I made sure I must be present to hear it. I have been exceedingly interested in all that has been brought to our attention, but have in mind several matters which have not been touched upon, and I am going to take advantage of an opportunity to ask still other questions.

(1) What is the accuracy of an A.C. ammeter used with a series transformer as compared with the accuracy of the same instrument used straight in the A.C. circuit? For example, suppose I have an inclined coil Thompson ammeter, range 0–25 amperes, used to measure 20 amperes; and again with a series transformer of the ordinary commercial type having a transforming ratio of 10–1 used to measure 200 amperes. What relative accuracy of reading may be expected? Will the instrument make the second reading correctly by using a multiple of 10 for scale readings? Will the instrument measure 200 amperes with a less accuracy than 20 amperes?

(2) What is the accuracy of an A.C. wattmeter used with transformers in circuit of both the current and potential coils, as compared with the accuracy when used direct? For example, suppose I have an inclined coil Thompson wattmeter, range 2,500 watts, and I use this directly to measure the power in a circuit where 20 amperes at 100

volts is used; and again I use the same instrument with potential and current transformers, each having a ratio of 10–1 on a circuit carrying 200 amperes at 1,000 volts?

In both questions I have in mind commercial apparatus and commercial conditions, and ask them because the connection of A.C. instruments with transformers is so common now. Without thinking it out in detail, or making any experimental trial, it seems to me that in case of the wattmeter for example, not only will the accuracy of the instrument be affected by the regulation in the transformers used and by variation in frequency of the applied E.M.F., but some little also due to changed phase relations between current and E.M.F. after their transformation.

(3) How much will the accuracy of the wattmeter in question 2 be further affected by using the same current transformer not only for the wattmeter but for an ammeter and perhaps for a recording wattmeter as well? By interposing the other instruments in the circuit of the secondary of the series transformer the impedance of this circuit is considerably increased without increase of E.M.F. to get current through it.

Any information on these matters which Mr. Haskins may be ready to give will be highly appreciated.

MR. HASKINS: The character of Professor Rowland's first question is such that no specific answer can be made. The accuracy of an ammeter combined with a current transformer is not quite equal to the accuracy of the instrument alone, but the additional error introduced by the transformer may be so minute as to be entirely negligible. It is much dependent upon two conditions which I will explain.

It should be borne in mind that with a combination of ammeter and transformer we are dealing with the errors of two devices instead of one, and these errors may be cumulative or the opposite. If an individual ammeter is calibrated with an individual transformer, then the characteristic variations of ratio which may characterize that transformer are corrected in the scale calibration of the ammeter; but for practical reasons it is frequently desirable to utilize

ammeters and current transformers, which are interchangeable. Under these conditions the accuracy of the ammeter depends upon the uniformity of ratio of the transformers used. The ammeter may either be calibrated to correct the errors of ratio at different loads which characterize a whole line of transformers, and the transformers may be checked against this calibration standard; but if the transformer is to be used in connection with recording meters as well as indicating instruments, then the correction of ratio error in the transformer on the scale of the ammeter is not permissible, as similar corrections cannot be made in recording meters, and therefore, a current transformer having a substantially unvarying ratio through its useful range must be resorted to. In practice, a range of from one-tenth to full load is all that can be expected from a current transformer. This is unimportant, as it should be remembered that no indicating instrument ought to be regarded as accurate at loads of less than 25 per cent. of the maximum scale. The accuracy of a current transformer through the specified range is entirely dependent upon the proportioning of its parts, the character of the iron used and the portion of the saturation curve at which the iron is worked. It is obvious that iron in such transformers should be worked at low saturations, or through that portion of the iron curve where the lines per square inch increase in direct ratio to the increase of current in the primary.

The above, I think, answers both questions 1 and 2 propounded by Prof. Rowland. The answers cannot be made more specific, as the results obtained are entirely dependent upon the design and character of the current or potential transformer used. It is proper to point out, that the use of both current and potential transformers is prompted primarily by motives of safety and convenience, and their use is confined and should be confined to measurements in connection with high potential systems where it is undesirable to directly connect the instrument to the system, or to alternating systems of large current volume where a current transformer is used as a matter of convenience, sometimes almost of necessity, as is the case with the shunt in connection with direct current instruments.

It should also be pointed out that there are inherent errors in alternating current ammeters of very large current capacity, due to foucault currents and other similar causes, which, in connection with measurements of large current volume, render the results obtainable with a current transformer more generally reliable than those obtainable with an instrument connected direct.

Prof. Rowland is correct in assuming that the accuracy of a wattmeter will be affected by any errors of regulation in the transformer, and these errors of regulation must be eliminated by correct design.

Prof. Rowland is also correct in assuming that variations of frequency may similarly affect the instrument, but in a correctly designed current or potential transformer such errors may be so nearly eliminated as to be practically incapable of detection through the range to which such variations are commonly confined.

With reference to question 3. If the current transformer be designed to carry a load upon its secondary equivalent to the several instruments in series cited by Prof. Rowland, then the addition of these instruments to the secondary will not affect the wattmeter. It is customary in practice to so design current tranformers as to permit of a specific load, which may be made up of one or more instruments, the sum of which does not constitute a load exceeding certain ohmic or inductive resistance. This question also is entirely a question of correct transformer design.

THE ELECTRIC LIGHT IN EXAMINATION OF GEMS.

According to the *Electrical World and Engineer*, M. Chaumet, in Paris, has recently made some experiments with a view to the use of such rays in the determination of the value of gems. Becquerel ainé noted years ago the fluorescence of diamonds under the influence of various colored rays. Chaumet has ascertained that there is a close relationship between this fluorescent property and the brilliancy of diamonds under artificial light, particularly candlelight, which brings out most clearly the quality of first-class stones. Diamonds that sparkle most vividly are not always those cut in the most regular shape, but those showing the greatest amount of fluorescence when examined with violet light. While diamonds that are non-fluorescent when exposed to this light simply take a violet coloration, the most sparkling stones show a

notable fluorescence of a very luminous and clear blue. Diamonds, whatever their quality, always offer the same transparency to Röntgen rays, so that it is impossible to differentiate them by means of radiography. In a jewel-case in which are grouped diamonds of all qualities, the gems, when illuminated by violet light, assume different tints, some showing a vivid blue brillance, while others are of a sombre violet. As soon as the electric lamp is put out, all degrees of phosphorescence are noticeable, the jewel-case appearing to be studded with violet or blue glow-worms—some very bright, others almost extinct; and the most sparkling stone will be found to be the best. In the course of his experiments, M. Chaumet has observed a curious fact with respect to a yellow diamond with numerous facets which showed remarkable golden reflections in daylight as well as in artificial light. The violet light produced no fluorescence in this case, but gave rise in places to flashes of an intensely red color, particularly noticeable on the feather-edged sides. A violet pencil of rays was projected upon this yellow diamond for a few minutes, when the experimenter found to his surprise that the yellow color had changed to dark brown, the stone thus losing four-fifths of its commercial value, which, however, was recovered after some hours. In experimenting on the action of the various rays on rubies, M. Chaumet has ascertained that the Siamese stones are of scarely appreciable fluorescence under violet light, while all the valuable Burmese rubies are intensely fluorescent, exhibiting a clear vivid red light that puts them in evidence when they are mixed with stones from Siam, which remain sombre.

NERNST LAMP GLOWER.

A defect of a solid Nernst lamp glower is its tendency to break down under currents of considerable volume, by reason of the central portion of the glower becoming fused by the current. In a patent issued December 30th to Henry Noel Potter, a glower is described which is designed to obviate this defect. The glower is in the form of a hollow tube, with the terminal wires twisted about the ends and covered with a pasty material similar in composition to that of the glower proper.—*Electrical World.*

DENSITY OF THE EARTH.

In order to determine the density of the earth, President F. W. McNair, of the Michigan College of Mines, and Major John F. Hayford, of the United States Coast and Geodetic Survey, will conduct experiments at the Tamarack Mine, which is particularly well fitted for this purpose, since its shaft is one of the deepest in the world, penetrating to a depth of 4,550 feet in strata of uniform density. The density of the earth is largely a matter of scientific conjecture. It has been computed by formulæ based on Newton's laws of gravitation. It is true that Sir George Biddle Airy, the British Astronomer Royal, computed the earth's density from experiments which he carried on at a Welsh colliery, but the figures which he obtained varied so much from those based on the formulæ that they have not been generally accepted.—*Scientific American.*

Section of Photography and Microscopy.

Read at the Joint Meeting held December 11, 1902.

Notes on the Water-Supply in Ancient Jerusalem.

By Henry Leffmann.

Information obtained in recent years indicates that Jerusalem was a strategic point in Palestine at an early period, but its importance as a metropolis was, as usual, of slow growth. For many centuries the city has been little more than a sacred memory. It received severe treatment at the hands of the Cæsars; the Emperor Hadrian, in the second century of the common era, destroyed it as far as he could and renamed the site. This attempt to efface the Holy City from the memory of man failed miserably, but the material evidences of its golden era were largely obliterated.

We know comparatively little of the ancient world, but one fact stands out in strong contrast to the conditions of medieval life, and even of many modern cities, namely, the care taken to secure a good water-supply. The highest honor for this sanitary measure is justly given to the city of Rome, but this was by no means the first. It is only of late years that the details of the water-supply of ancient Jerusalem have been unearthed. The following description is compiled from various recent sources.

Jerusalem is on high ground, and is surrounded by valleys. Its walls enclose a space of less size and population than some of the wards of Philadelphia. It is known that in some of the severe sieges, the inhabitants suffered most for want of food while the besieging armies suffered most for want of water. From this it is to be inferred that either springs existed in the city or that water was conveyed in concealed conduits. The latter view is now known to be correct; possibly the former is also.

It is believed by the authorities that the earliest efforts

at impounding natural waters so as to secure a constant supply for use at or near Jerusalem began in Solomon's time by the building of reservoirs in the Kedron Valley (east and southeast of the city) for the supply of water to the royal gardens. This reservoir, called by Josephus, Solomon's Pool, cannot now be found. Later an open channel

FIG. 1.—Map of Southern Jerusalem and adjacent districts. The tortuous aqueduct from the Virgin's Spring is seen on the right, in the Kedron Valley.

was cut in the rock forming the west slope of the Kedron Valley, by which the water was led to a point where it was easily available to the residents of the city. It has been suggested that the words of Isaiah, viii, 6, "the waters of Shiloh that go softly," are an allusion to the flow in this conduit which has but a slight grade. The original channel was identified in 1866. A more interesting and impos-

ing work was carried out some 300 years after Solomon's time by Hezekiah who, prior to the Assyrian invasion, impounded the water of a spring to the east of Jerusalem and brought it down to the east side of the city. This work is mentioned in both the accounts of Hezekiah's reign; thus, in II. Kings, xx, 20, we read: "Now the rest of the acts of Hezekiah and all his might, and how he made the pool and conduit and brought water into the city, are they not written in the book of the Chronicles of the kings of Judah?" Turning to II. Chronicles, xxxii, 30, we read that Hezekiah "stopped the upper spring of the waters of Gihon and brought them straight down on the west side of the City of David." Palestine archeologists regard Gihon as identical with a spring now just ouside the city wall and known as the Fountain of the Virgin. The operation of Hezekiah involved the construction of a tunnel through rock in a tortuous course of over 1,000 feet, leading the water into two reservoirs near the southeast corner of the city. About twenty years ago an inscription in archaic Hebrew was found on the tunnel-wall near the lower end. The following is a translation of this inscription from a French version in *Rev. d. Etudes Juives*. I am indebted to Prof. Morris Jastrow for the reference to this translation, and also for an emendation of it, reading "blind alley" (cul-de-sac) instead of "accident" of the French text. "End of the boring. Here is what relates to the boring. While the borers worked their picks in opposing directions, and there were 3 cubits to break through, they heard each other's voices, for a blind alley was disclosed in the rock on the right and left, and on the day of completion the borers faced each other face to face. The waters ran from the pool-spring 1,200 cubits. The height of the rock above the borers' heads was 1 cubit."

The tortuous course appears intentional, for shafts were driven at two different points. It has been suggested that this course was rendered necessary to avoid rock-hewn tombs. The spring was intermittent, and has even been supposed to have a symbolic periodicity. It is an interesting example of how a legend may arise and be propagated,

that a traveler who visited Jerusalem in A.D. 333, and who is known in history as the Bordeaux pilgrim, states that the pool of Siloam was inside the walls of the city and that the waters did not flow on the Sabbath.

Excavations along the southern wall of Jerusalem have

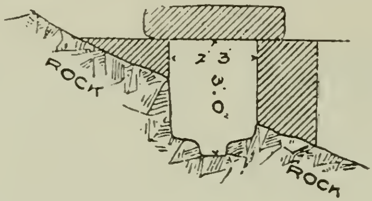


FIG. 2.—Cross-section of aqueduct.

brought to light an aqueduct passing along the northern slope of the Hinnom Valley, penetrating the wall and passing towards the southeast corner of the city. This aqueduct is well built, being hewn out of a rock with rather steep incline. The upper and lower sides were extended by

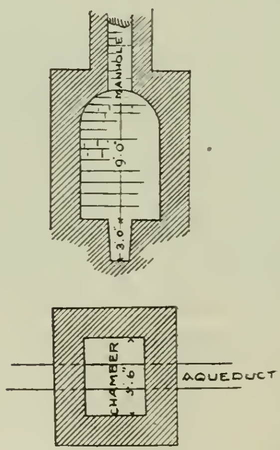


FIG. 3.—Cross-section of enlarged portion of aqueduct.

walls, so that flat cover-stones might be used. The cross-section of the channel is rectangular, with a depression in the center line of the floor. The dimensions are about 3 feet high and 2¼ feet wide. Rock-hewn manholes were provided. At one point there is a chamber 5½ feet long, 4 feet

wide, 9 feet high. F. J. Bliss, whose excellent work on the excavations at Jerusalem gives much information, thinks that this aqueduct is also the work of Solomon's time, but further information on this point is required.

In addition to these constructions, Bliss gives the lines of an aqueduct beginning to the west of Jerusalem, passing around by the south in the Hinnom Valley, and entering the city toward the east. This he terms the lower-water aqueduct, but gives no special information about it. We know from Josephus that Pontius Pilate "brought water into Jerusalem," but detailed information on this point is not available. His action provoked much dissatisfaction, possibly owing to exactions and oppressions practiced in carrying out the work. The name of this man has been anathema for so many centuries that we should not grudge him some honor for bringing in a new supply of water.

More extended excavations may be expected to yield still further interesting results as to the sanitary conditions of this ancient city.

ELECTROLYTIC REDUCTION OF LEAD.

On the subject of the electrolytic reduction of lead, Pedro G. Salom read a very interesting paper at the recent Philadelphia meeting of the American Electrochemical Society. He described the process invented by him and in use by the Electrical Lead Reduction Company at Niagara Falls. The ores that are reduced are sulphides of lead. They are used as cathodes in an acid electrolyte. The hydrogen ions combine with the sulphur of the ore and form hydrogen sulphide, which escapes as gas, while the lead sulphide is reduced to lead. This is the principle of the process. The apparatus used resembles in a general way a pile of dinner dishes of lead, piled one above the other. Each of these dishes represents a cell, the under side of a "dish" being the anode of the lower cell, the upper side the cathode of the upper cell. With forty-eight cells in series they use 130 volts and get 2 pounds of lead per horse-power hour.

The lead obtained in this process is in spongy form, and is then used for making other materials, like litharge. Owing to its spongy form, the lead is very readily transformed into litharge. Samples of spongy lead, compressed lead, litharge and other materials were shown. In future it is also intended to make accumulator plates.

The principal difficulty in the practical operation of the process was that the reduction was not complete, and that under apparently identical conditions the degree of reduction was not the same, especially as lumps of ore in the immediate neighborhood of the cathode plates were not reduced.

In the discussion which followed, the following explanation of this fact was offered: When the electrolysis begins, the parts of the ore near the electrolyte are reduced; when the electrolysis progresses the current may prefer to pass through the reduced lead to the cathode, hydrogen being developed and no lead sulphide being reduced. According to this view, the efficiency of the reduction would gradually diminish with progressing electrolysis. This would explain the fact that especially lumps of ore remote from the electrolyte are not reduced.

At present they have succeeded in improving the reduction so that about 92 to 95 per cent. of the lead sulphide is reduced to lead. Another difficulty experienced was that the workmen's eyes were affected during the operation by the escaping gases; but this difficulty appears to have been overcome.

As the developed gases are hydrogen sulphide and oxygen, in their combining proportions, it has been proposed to utilize them in gas engines, which then could develop more power than was used in the process. This apparent paradox was explained by Prof. J. W. Richards in the discussion.

The ores treated in the process contained no silver. No attempt is therefore made to refine the lead for producing silver.

MAGNITUDE OF COMMERCE ON THE LAKES.

The close of November on the Great Lakes usually marks the end of the season of through navigation; and the government statistics show that for the first eleven months of the past year, 77,408 vessels, of over 71,000,000 net tonnage, were reported as arrivals, and 77,899 clearances were reported, of over 72,000,000 net tons. There are twenty indvidual ports on the Great Lakes having a registered tonnage ranging from 1,000,000 to over 5,000,000 tons. Cleveland heads the list with 5,037,282 tons; and other ports, viz.: Duluth, West Superior, Milwaukee, Chicago and Buffalo, recorded over 4,000,000 tons of arrivals. The enormous volume of this movement is only appreciated when it is compared with similar marine operations on the ocean frontage. New York, during the entire year 1902, is credited with 8,982,767 tons of arrivals; London had entrances in 1901 amounting to 9,992,753 tons; and Hong Kong reported 8,626,614 tons entering in the year 1900.—*Scientific American.*

METALS IN THE HOUSEHOLD, ETC.

Professor Lehmann has reported on the significance of the hygienically important metals, aluminium, lead, copper, nickel, tin and zinc, in the household and in the food branches, at the meeting of the German Verein fuer oeffentliche Gesundheitspflege. Actually injurious and dangerous are lead and all lead preparations. Mercury poisoning in the household is too rare to deserve any mention. The poisonousness of copper, zinc and tin is very slight and greatly exaggerated by some authors. Silver, aluminium, iron and nickel may be called entirely harmless. Despite the slight hygenic value of all heavy metals, excepting lead and quicksilver, all endeavors to keep these metals away from our aliments, especially preserves, should be assisted.—*Neueste Erfindungen und Erfahrungen.*

CHEMICAL SECTION.

Stated Meeting, held Thursday, January 23, 1902.

Modern Methods of Rock and Mineral Analysis.

BY DR. W. F. HILLEBRAND,
U. S. Geological Survey, Washington, D. C.

Since those days in the life of our science, when the study of organic compounds being as yet hardly begun, much more of the time of the foremost chemical workers was devoted to the elucidation of the composition of minerals than was later and is now the case, the conditions governing chemical work have changed greatly. When rubber tubing was a thing unpurchasable and had to be made when wanted by the tedious process of pressing the edges of a strip of soft sheet-rubber together into an air-tight seam over a glass or other rod of the desired size; when the various reagents, too, had to be mostly made, and alcohol-lamps and charcoal-furnaces furnished the only means of procuring high temperature; when all the modern conveniences of an ordinarily well-equipped laboratory were lacking —filter-pumps, spectroscopes, electricity on tap at a moment's notice—at that time it was well perhaps that the chemical complexity of the earth's crust was so little suspected, else he had been a bold man who would tackle the composition of many of our common stones and useful minerals. Gallium, indium, thallium, germanium, with nearly all the growing host of rare earths, were to be discovered. It was long before titanium (about tenth in order of abundance) became recognized as more than a rarity among elements; and as to vanadium, now entering the lists of those eagerly sought by industrial interests, it was but one of many chemical curiosities whose commercial possibilities were undreamed of.

His was therefore a simple task in some respects compared with that of the analyst of to-day, yet, considering the means at his disposal, the results achieved are a stand-

ing monument to the skill and untiring perseverance of the great minds of those times. It is no discredit to them that their work in rock and mineral analysis is so little available to-day because of the higher requirements of modern classification both as to the quality and quantity of the ingredients.

It is in some respects surprising perhaps that the fundamental methods of chemical separation employed then remain in use so largely to-day, modified oftentimes in the direction of greater accuracy or simplicity as perception of the mechanism of the reactions involved has become clearer, but unchanged in principle.

Comparison of the methods of the present with those of the past is hampered by the difficulty, nay, impossibility, of deciding where yesterday ended and to-day began. There is no well-marked milepost dividing the one from the other, unless we choose to regard as such the introduction of heavy solutions for the purpose of obtaining in greater purity and quantity than was otherwise possible one or more of the constituents of a mineral mixture. While it is incontestable that the use of these solutions has done more to advance the study of minerals, particularly of those making up the complex rocks, than any one other thing, it has done so solely for the reason that we are thus often enabled to obtain our material in greater purity than heretofore and not because it has influenced in any way the chemical side of the problem.

Instead, therefore, of trying to establish an imaginary line it will perhaps be simpler to outline a small portion of the present practice and to show here and there wherein and why it differs from that of earlier times. My remarks will apply less to the technical than to the scientific application of methods. In general, the investigation of minerals and rocks requires far more searching work than the ordinary problems of technology, yet it is largely by the observations made along this purely scientific line that necessary improvements in the latter work are indicated and provided. This is but a minor repetition of the oft-repeated observation that the apparently unimportant discovery in

pure science of to-day may be worth fortunes to individuals and incalculable benefit to mankind in the future.

Instead of drawing my first examples from the simply constituted minerals and gradually leading up to those of a complex nature, I will plunge at once into that maze of complexity, a silicate-rock analysis. This I do to avoid the useless repetition that would result through working up from simple to complex compounds and finishing with the most complex of all, and for these other reasons: In the igneous rocks are probably to be found nearly all the elements existent in the outer regions at least of our globe, as is but natural, since the secondary geological formations and minerals must have had their origin in the former. The methods used for the separation of their numerous constituents are in large part those which would be employed in analyzing these latter separately; modified, however, oftentimes by the fact that many of these components are of very subordinate occurrence and hence require or admit of different treatment than if they were chief constituents.

A further reason for my choice of a working illustration is that the study of the composition of simple minerals is but an incident in the work of mineral chemists compared with that of the complex rocks whose classification is now demanding the best efforts of petrographers the world over. This problem calls for an ever-increasing number of analyses in order that the relations between the rapidly growing number of variations in rock species may be traced by affording the necessary chemical data without which no system of classification can be successfully evolved.

It is only in recent years that the need of exhaustive and elaborate analyses of rocks has come to be recognized by petrographers, and there are many who are still quite content with results which were generally deemed all-sufficient forty or thirty or even twenty years ago. Those workers who are trying to solve the great problem of rock-classification find themselves more and more hampered by their growing inability to make anything like adequate use of the great array of chemical data coming down to them from an earlier period, and even, be it said, of much of that of to-day.

This is not to be wondered at when it is recollected that such constituents as phosphorus and titanium, averaging together about 0·8 per cent. of the rock-crust of our globe, were seldom looked for; that the utterly untrustworthy "loss-on-ignition" method was usually deemed sufficient for water, and that such constituents as barium, strontium and vanadium were practically undreamed of as rock-constituents. I have pointed out on other occasions the erroneous conclusions that must of necessity follow from such defective work, yet I do not think that any apology is needed if I again draw attention to an example.

	a. Earlier Analysis.	*a.* Later Analysis.	*b.* Earlier Analysis.	*b.* Later Analysis.
SiO_2	54·42	53·70	44·31	44·65
TiO_2		1·92		·95
ZrO_2		·20		
Al_2O_3	13·37	10·96	17·20	13·87
Cr_2O_3		·04		
Fe_2O_3	·61	3·10	4·64	6·06
FeO	3·52	1·21	3·73	2·94
MnO		·04	·10	·17
CaO	4·38	3·46	10·40	9·57
SrO		·19		·37
BaO		·62		·76
MgO	6·37	6·44	6·57	5·15
K_2O	10·73	11·16	3·64	4·49
Na_2O	1·60	1·67	4·45	5·67
Li_2O	trace.	trace.		trace.
H_2O 110° —		·80	·77	·95
H_2O 110° +	2·76	2·61		2·10
H_2O ignition			3·50	
CO_2	1·82			·11
P_2O_5		1·75		1·50
SO_3		·06		·61
F		·44		
Cl		·03		trace.
	99·58	100·40	99·11	99·92

These analyses were made by different chemists, and in the first case at widely separated times and on specimens collected by different geologists, but nevertheless, from the same rock-mass, in which, however, much the relative proportions of the different mineral constituents might vary within certain limits, there can be no reason to doubt the

general distribution of all the elements shown by the later analysis.

What wonder is it that no satisfactory conclusions result from an attempt to calculate the mineral composition of these rocks from the early analyses, wherein from 3 to 4 per cent. of acidic oxides have been overlooked, with the further result that the bases have been found too high to the extent of the neglected titanium and phosphorous oxides which were mostly weighed with the alumina? If, by chance, calculation had led to seemingly satisfactory balancing of acidic and basic oxides, the result would be decidedly more unfortunate than if this had not been the case, for it would have tended to establish the rock in an altogether erroneous position, whereas, otherwise, at the worst its position would be so in doubt as to lead perhaps eventually to a re-analysis.

The custom of neglecting to make preliminary qualitative tests in rock analysis is the prime cause of many gross errors like the above, but this neglect is doubtless attributable to lack of time for their execution, since some are not altogether simple or to be disposed of in a few moments.

In analyzing minerals as distinguished from rocks, errors of the kind above noted are less frequent. There it is and always has been the almost invariable custom to make a careful qualitative analysis first, and not to assume the presence of only a few unvarying constituents in measurable amounts.

The difficulty in the way of attaining correct and easily interpretable results was mainly due to lack of means for ascertaining whether or not the material was pure (especially with uncrystallized material), and still more perhaps to inability to identify or to separate the certain or suspected impurity or admixture. Of course, if its composition were known, this might now and then be allowed for in calculating a formula, but if unknown, any result must be more or less affected with doubt. The polarizing microscope has done much to overcome the first of these difficulties, and in the case of rocks to afford invaluable hints to the chemist as to what unusual constituents he should be on the lookout for or for what commoner constituent in quantities out

of the ordinary. And by the use of the so-called heavy solutions mysteries have been solved which hitherto had resisted the ablest efforts of master-hands and minds; for by their aid has it been possible often and often to obtain material of a degree of purity quite unattainable by panning or laborious hand-picking, or partial attack by acids, or any combination of these processes.

These two devices, the polarizing microscope and heavy solutions, have done quite as much, if not more, to help the mineral chemist than the perfecting of methods or better understanding of the chemical behavior of compounds he has to deal with.

Until the application of these solutions become known the petrographer must needs calculate the relative proportions of his rock minerals from the bulk analysis and assumed compositions for the constituent minerals, and thereby run often into error, for he could by no means always be sure that his minerals had in fact the composition assumed for them. Now, however, he can, when necessary, separate them from one another, analyze one or several of them, and discuss the results of the bulk analysis with confidence instead of doubt.

While the use of heavy solutions does not pertain to the domain of chemistry, they play such an important part in the preparation of material, and are so often employed by the chemist himself, that brief descriptions of the agents themselves and their manner of utilization may be regarded as a fitting prelude to the chemical side of this paper.

HEAVY SOLUTIONS AND SEPARATORY APPARATUS.

Although the idea of separating mixed solids by taking advantage of their difference in density was long ago suggested and to a slight extent applied, as by using an upward current of water or a solution of mercuric nitrate, the first of the so-called heavy solutions to come into general employment was a double iodide of mercury and potassium, first proposed by Sonnstadt in 1873. It therefore properly bears his name, though it is more commonly called by that of Thoulet, who first devised an apparatus for its convenient

use. After Goldschmidt had studied the subject exhaustively and showed the great value in several ways of the solution, as well as defined its limitations, petrographers first became fully awake to the fact that a powerful handmaiden had arisen to further the strong advance inaugurated by the polarizing microscope.

This solution is made by dissolving potassium iodide and mercuric iodide in proportion of 1:1.239 in a minimum quantity of water. The maximum density attainable by evaporation of this solution is generally stated to be 3.196, but I have had no trouble in reaching repeatedly 3.25 and over. By dilution with water this can be reduced as desired. The majority of rock-forming minerals can be separated by this solution, and it is the simplest to make and the easiest to use perhaps of all similar solutions, though somewhat corrosive in its action on the skin and suffering from one drawback incident in its relatively low density compared with other heavy solutions in use, namely, that many minerals have a density superior to its maximum. For the separation of these from one another, solutions of greater density had to be sought, and were before long forthcoming.

The Frenchman, Klein, introduced cadmium-boro-tungstate, either in concentrated solution with a maximum density of 3·36 or in fusion at 75° C., when its density reaches 3·58. But its preparation is extraordinarily difficult and uncertain, and it undergoes somewhat ready decomposition with separation of a white deposit which cannot again be brought into solution.

Rorbachs' solution of barium-mercuric iodide, attaining a maximum solution density of 3·588, is useful at times for minerals heavier than the Sonnstadt solution. Its proneness to decompose when diluted with water renders it less serviceable for lighter bodies.

Methylene iodide of density 3·3155 at 20° C., because of its mobility, has been well spoken of in recent years, but I have had no opportunity as yet to test it. Dilution in this case has to be effected by benzol or toluol.

Mixtures in varying proportions of thallium and silver nitrates are useful on occasion for separating minerals

heavier than any of the agents already spoken of. These are used in fused condition, the equi-molecular mixture having a fusion density of 4·5 at 75° C. By increasing the proportion of thallium, heavier compounds fusing at higher temperatures are obtained, till with 1 $AgNO_3$ to 4 $TlNO_3$ the density is 4·94 and fusing temperature 250° C. It is disagreeable to handle because of staining the skin, and as a good substitute, mercurous-thallium nitrate has been proposed.

Then there is the fused mixture of lead and zinc chlorides with density 4–5.

In using these various agents certain precautions have to be observed; for instance, the Sonnstadt solution is attacked by some metallic substances, as iron, zinc, nickel, also perhaps slowly by sulphides and certain oxides; hence, it becomes in time seriously contaminated and darkens in color. This last defect is soon corrected, however, by digestion of the liquid with metallic mercury. The maximum density suffers somewhat in consequence, after a time, but with ordinary care the same solution may be used for many years with little impairment of density.

The cadmium-boro-tungstate solution likewise attacks metals and also carbonates, while the silver-thallium nitrate attacks most, if not all, sulphides.

In making separations by these solutions it is useless to expect quantitative results with natural mixtures. There is always too much intergrowth or inclusion of different minerals, no matter how fine the subdivision may be. This comminution cannot be carried beyond a certain limit either, because of the extreme slowness of separation of very fine particles, just as with clay suspended in water; consequently, there is almost always a waste, and often a very great waste of substance. The first separated portions must usually be again treated with fresh solution in order to remove foreign grains carried down or up with the material which it is desired to obtain pure. Careful examination with the polarizing microscope must decide as to the condition of the ultimate product.

With some solutions, especially the Sonnstadt, these

separations can be made in ordinary breakers or crystallizing dishes, or straight-sided separatory funnels, particularly the first crude separations. But usually special apparatus are employed which allow more ready removal of the heavy portions of mineral than is possible with those vessels which, like beakers, have no outlet at the bottom. Some of these I will now show and explain the manner of operation. [At this point various forms of separatory apparatus were exhibited and described.]

SPECIFIC GRAVITY BY HEAVY SOLUTIONS.

Having now obtained our material in a condition fit for analysis, I will not take up time in telling how its specific gravity may be determined, except in so far as this is done indirectly by means of some of those same heavy solutions of which I have just spoken. The specific gravity of a solution in which a fragment of rock or mineral remains suspended at any depth, without rising or sinking, is necessarily the specific gravity of that fragment. Hence, in making separations by the aid of solutions which are liquid at room-temperatures, it is often convenient to determine the density of the liquid wherein a particular mineral neither sinks nor swims in order to know that of the latter. This is most conveniently done in a few moments by the Westphal balance. Since in crushed condition not all grains or fragments of a mineral possess exactly the same density, we have here a handy means of ascertaining the extreme limits of density of all the grains. It is only necessary to determine the density of the liquid in which a few grains begin to fall and again after diluting it till all have fallen. Especially convenient for density determinations are the heavy solutions when but a few small fragments are available, insufficient for determination by the usual methods.

DISCUSSION OF CHEMICAL METHODS.

I will now begin the chemical discussion by briefly considering a method for the breaking up of silicates more or less insoluble in hydrochloric acid—a method discovered prior to 1805 by Sir Humphrey Davy and rather recently reju-

venated by the German chemist, P. Jannasch, who expects it to entirely supersede the sodium-carbonate method of fusion for most fine work. This latter method, as you are aware, introduces a large amount of fixed alkali salt into the analysis, whereby the thorough washing of precipitates is rendered difficult.

Jannasch decomposes the silicate by fusion with pure fused boric oxide, using the oxy-gas flame for certain silicates like andalusite, cyanite and topaz, which are not fully decomposed over the ordinary blast.

After transferring the contents of the crucible to a large dish the boric oxide is driven off as boric ether, by digesting and subsequently evaporating several times with a saturated solution of hydrochloric acid in methyl alcohol.

Very much is claimed for this method by its authors and it is manifestly superior to the alkali carbonate method when material is scanty, for it admits of determining the alkalies in the same portion as the silica, lime, manganese, etc. As yet I have been unable to submit the method to critical test and am unable to express an opinion as to its real merits, though I hope to be able to do so before another year passes. One or two objections occur to me which probably are well founded, in part at least, but there is no question apparently that at times the method may render inestimable service. It will, however, probably not displace the sodium-carbonate method in technical work, even should it do so to a large extent where the extreme of accuracy is desired.

For the determination of certain constituents in silicates the method offers little or no advantage, or is even not at all adapted, as for instance, phosphorous, arsenic, vanadium, sulphur, chlorine, fluorine.

In connection with this last element an interesting observation was made by Jannasch and Weber, which it is my intention to look further into. They found that over the oxy-gas blast fluorine, if present, was wholly driven off as fluoride of boron without involving any loss of silica as silicon fluoride. An easy means seems to be thus afforded for determining silica in fluorine minerals where even its detec-

tion in small quantity has heretofore been difficult in the last degree, if not impossible.

I will now take up the question of the ordinary determination of this compound silica which constitutes the major part of the solid crust of our globe. The ordinary method for its determination is, of course, familiar to you all, yet how far short of perfection it is, especially when, as is usually the case, the chemist is wholly or partially ignorant of its defects, the following list of determinations shows:

	Raw Cement Mixture. SiO_2	Per Cent.	Finished Cement. SiO_2	Per Cent.
Standard.	15·18	100·	21·31	100·
1	15·75	103·7	20·90	98·1
1a	15·37	101·2	—	—
2	14·68	96·7	20·92	98·2
3	13·92	91·7	20·06	94·1
4	—	—	20·00	93·9
5	14·18	93·4	20·26	95·1
6	14·70	96·8	20·96	98·4
7	12·78	83·7	20·84	97·8
8	13·97	92·0	19·82	90·5
9	14·44	95·4	20·76	97·4
10	13·60	89·6	19·18	90·0
11	14·64	96·4	21·46	100·3
12	14·18	93·4	20·76	97·4
13	14·92	98·3	21·56	101·2
14	13·56	89·3	19·53	91·2

The results of this table formed the basis for a paper, an abstract of which I delivered in this city less than a month ago, and a part of what I am now about to say will therefore bear a familiar sound to those of you who were present at that time.

The figures represent silica determinations in the same samples of raw-cement mixture and of finished cement from this mixture, made by fifteen different chemists at the request of a committee of the New York Section of the Society of Chemical Industry for promoting uniformity in technical analysis. My own connection with the work was that I was requested to analyze the samples with the care usually bestowed on rock and mineral analysis in the Geological Survey Laboratory, in order to learn exactly the

composition of these samples and thus to have a standard for comparison. The first determinations of the list represent the standards, which are probably in error by 0·1 per cent. to 0·2 per cent. at most, that of the finished cement being possibly as much as 0·2 per cent. too low. Later, after all the data, including methods used, had been collected, copies of these were turned over to me for critical examination as to the causes for the grave discrepancies in most of the analyses and for suggestions looking toward the removal of these causes. It should be understood that the most of these analyses were made for technical purposes, and that only the care usual in such cases was expended on them.

I can very well recall, when making my first silicate analysis under the revered Bunsen, that we evaporated the hydrochloric solution of a rock, after fusing with sodium carbonate, for six to twelve or more hours on the water bath to insure perfect insolubility of the silica. Then, at a subsequent stage in the analysis we dissolved our ignited precipitate of iron and alumina in hydrochloric acid and filtered from a small residue of silica. What to do with this, whether to regard it as belonging to the rock or as derived from the porcelain dish used for evaporating or from the beaker in which precipitation was made, or from these and reagents as well, was never made clear to me, but my impression is that we rejected it.

Now, while a portion of this silica may have had and doubtless did have its origin in other sources than the rock, experience of many years has taught that it is mainly to be ascribed to incomplete separation by evaporation of all that was in the rock, and hence arose the custom in all really careful work to recover from the iron and alumina that which had escaped and accompanied these other bodies when they in turn were precipitated. As recent experiments of mine have shown, this last procedure involves two errors which had hitherto been hardly more than suspected, and the detection of which emphasized all the more strongly the recommendation of Cameron made a number of years ago to remove all silica at the start by several alternating

evaporations and filtrations. It has been my own practice ever since that time to evaporate once to moderate dryness, then filter, then evaporate again to thorough dryness, and thus recover all but a very slight amount of the total silica. Cameron showed, and I have been able fully to confirm his statements, that it is impossible to render silica insoluble by evaporation to dryness, no matter how prolonged the drying may be or at what temperature it may be carried out, if only one filtration is made. Cameron, in his third and fourth filtrates, still found appreciable quantities of silica. My own results were more favorable, as from the second filtrate I never recovered more than a milligram of silica, and often much less. I ascribe this latter success to the fact that I used platinum instead of porcelain dishes.

The bearing of these remarks upon the figures of the table becomes plain when it is learned that in no case but the standard and No. 1 does it appear that a second evaporation and filtration were carried out, although it is evident from their descriptions that all the chemists strove honestly, according to conventional methods of dehydrating silica, to secure its complete separation.

There has long been found a statement in text-books that silica thus separated from solution needs to be strongly blasted to bring it to correct and unchangeable weight. The statement is unqualifiedly true in spite of a contrary one in Treadwell's recent text-book on quantitative analysis, which is based on experiments of Lunge and Millberg with silica derived from silicon-tetrafluoride. The condition of silica thus obtained seems to differ from that of silica precipitated from a silicate by hydrochloric acid in the ordinary course of analysis. The errors resulting from a failure to apply the blast to this latter form of silica are shown by Table III, which represents experiments on quartz 99·88 per cent. pure. In these cases the blast was applied for half an hour, after one hour's exposure to the heat of a good Bunsen flame, and yet the results are a little high in most cases and could have been lowered still more by doubling the time of blasting.

TABLE III.

		Silica found.			Percentage found.	
	Quartz.	Burner 1 hour.	Blast ½ hour.	Loss in weight.	Burner.	Blast.
1	·5738	·5761	·5735	·0026	100·40	99·95
2	·5931	·5945	·5930	·0015	100·24	99 98
3	·6401	·6450	·6394	·0056	100·76	99·90
4	·6638	·6668	·6628	·0040	100.45	99·85
5	·7028	·7058			100·25	
6	·7309	·7342	·7306	·0036	100·45	99·96
7	·8208	·8271	·8206	·0065	100·77	99·98
8	·8495	·8521	·8484	·0037	100 31	99·88
9	·8943	·8996	·8936	·0060	100·59	99·92
10		·9989	·9898	·0091		

Now, as it happens, but few of the silicas of Table II were blasted; moreover, not all or many of them were corrected by hydrofluoric acid for the invariably contaminating impurities, which in case of very basic rocks rich in iron, titanium and phosphorus may reach the sum of 1½ centigrams, or even more in extreme cases, where a gram of rock sample is under treatment. Hence, the results as given are in most cases still too high, and the excesses of a few over the standard are thus seen to be probably apparent rather than real.

The analyses under discussion did not end with determination of silica. Other constituents were determined, and it was noted that the sum of iron, titanium, aluminum, and phosphorous oxides was in almost every case markedly in excess of that of the standard analysis. From what has been said, the cause of this excess is plainly the precipitation and weighing of most of the missing silica with the oxides mentioned. Most, but not all; for while a large excess of ferric or aluminum hydroxide carries down with it a large part of the silica in solution, a portion of this last escapes precipitation and passes on into the filtrate. With a double precipitation the loss is of course increased. This is one of the errors I mentioned a few moments ago and which I have recently found in a number of tests to range between ·0007 gram and ·0023 gram for a single precipitation. The silica thus lost probably passes mainly into the final filtrate from the magnesian phosphate and escapes

estimation entirely. The second of the errors I will now consider.

Many chemists practise the custom of fusing the ignited alumina and ferric oxide with potassium pyrosulphate, in order to recover the silica contained in them, and probably considered the recovery nearly perfect; at least, I do not recall any expression of doubt on this point. That it is, however, very far from perfect was shown in the paper read in this city a few weeks ago and to which I have already referred. On dissolving the fused mass in water or dilute acid a considerable proportion—several milligrams—of silica may go into solution. It is true that, by adding to the solution-excess of sulphuric acid and evaporating till fumes come off strongly, the dissolved silica can be rendered insoluble and recovered; but this course was never pursued, because its need was unrecognized.

We thus have an additional and strong argument in favor of removing all silica at the start by two, or maybe even three evaporations, with as many filtrations.

I have dwelt thus at length upon the determination of silica not only because it is of such common occurrence and constitutes so often a large percentage of the substance analyzed, but also because uncorrected errors, like those described, do not end there but affect later estimations of other substances in the same portion of sample.

Passing now to the determination of the several components of the rock that may be collected together by means of ammonia or the basic acetate process, we find that the more modern changes in the manner of effecting their joint precipitation have aimed at greater perfection of separation without introducing any radical modifications in the methods themselves. It is now fully recognized that two precipitations by ammonia are necessary to free from calcium unless carbon dioxide is carefully excluded from contact with the ammoniacal liquid, and that unless large amounts of ammoniacal salts are present many times two will not suffice to keep magnesia out of the precipitate. Ignorance or neglect of this precaution has been the cause of countless faulty analyses. With very large magnesia

content, and much iron or aluminum, three precipitations may be necessary, even with a sufficiency of ammoniacal salts.

It is still the custom with most chemists to boil until all excess of ammonia is expelled, not only to effect resolution of precipitated magnesia but also to complete, as supposed, the removal of the last traces of alumina from solution, notwithstanding that both Genth and Penfield long since showed that the presence of alumina in the filtrate was due to prolonged washing with water much more than, if at all, to the solvent effect of ammonia in excess, and that Penfield, by the use of wash-water containing about 4 per cent. of ammonium nitrate, obtained filtrates almost entirely free from alumina.

The basic-acetate method has been the subject of innumerable researches having in view the molding of it into such shape that it might be depended on to give satisfaction in all hands, but undeniably without complete success. It has been shown that an undue excess of acetate should be avoided, and turbid filtrates can generally be prevented by adding a little of the precipitant to the wash-water. The testimony of different writers as to the efficacy of this agent as a means of separating iron from nickel, cobalt, and manganese is still conflicting, some maintaining its adequacy, others preferring to precipitate several times by ammonia in presence of much ammoniacal salt.

The collection by one or the other of the means outlined of all precipitable bodies that may be in the original solution being thus accomplished, the question now arises how to separately determine them after their combined weights have been ascertained. There is a well-founded prejudice against estimating a constituent of a mixture by difference if it can be equally well determined directly, but there are those who allow their prejudice to carry them too far. If the mixture is simple, the separate determination of each component may be exact and more or less easy, but if complex, this is not often so. For instance, there is no particular difficulty in dividing satisfactorily a mixture of iron and aluminum oxides into its component parts and weighing

each separately. If titanium forms a third component the task is more arduous though still possible, but with the addition of phosphorous, either with or without the titanium, the uncertainty is increased to such an extent as to render the choice of an indirect method for one of the components almost imperative. When vanadium, chromium, perhaps zirconium and rare earths, one or all, are included in our mixture, the task is a hopeless one, for each requires its special reagent for gravimetric, volumetric, or colorimetric estimation, whereby impurities or other disturbing factors are introduced to cloud each successive step.

In any mixture of the above-mentioned compounds there are reliable and direct means of estimating all except one, provided that they need not all be sought in the same aliquot part. This one is alumina. By no method or combination of methods with which I am familiar can, from such a mixture containing phosphorous, the alumina be isolated except by the introduction of probable errors far outweighing those incidental to its indirect determination. Therefore I regard it as far more accurate ordinarily to obtain the gross weight of all components of the mixture, then to determine all of its components but the alumina, partly in separate portions of the sample, partly in our weighed mixture, to deduct their sum from the known weight of all, and thus to arrive at the weight of the final unknown quantity. This course necessarily presupposes that the utmost pains were taken to obtain the mixture free from all contamination and of fixed and invariable condition of oxidation.

The objections which others have held or still hold are mainly founded on ignorance or disregard of the oftentimes complex nature of this precipitate produced by ammonia or sodium acetate. So long as the lesser constituents were not known, or were supposed to occur in only negligible traces, these objections had a basis for argument which with fuller knowledge no longer obtains.

Taking up now the methods of separating and estimating the constituents of this mixture I have so often alluded to, we find that important changes have been introduced in the

best practice, both as to the means of separation and ultimate determination. Titanium, which was such a bugbear in former years, is now one of the elements whose quantitative estimation offers few difficulties by colorimetry, if not in excess of a few per cent., otherwise by the excellent Gooch method, if zirconium is not at the same time present.

The old-time method of long boiling of the nearly neutralized and very dilute sulphate solution in presence of excess of sulphur dioxide to reduce and prevent co-precipitation of ferric iron, with its uncertainties and inconveniencies is, in this country at least, practically abandoned. The method so carefully worked out by Gooch depends upon the precipitation of titanium by boiling its sulphate solution, whose excess of acid has been neutralized by sodium acetate and to which then a certain measured excess of acetic acid has been added for the purpose of holding up alumina. Iron is supposed to have been first removed by ammonium sulphide in tartaric solution, the excess of tartrate being then destroyed by permanganate before precipitation of the titanium.

Zirconium, a frequent constituent of rocks, has been found to interfere with this gravimetric estimation by holding up much or all of the titanium. Hence, for rock-work, where titanium is not in great amount, the colorimetric method offers opportunity for its easy and exact determination. This, devised by Weller, and studied further by Dunnington and myself, consists in the oxidation of a sulphate solution of titanium by hydrogen peroxide, whereby the solution becomes colored a powerful yellow to reddish orange admitting of ready comparison with a standard solution similarly peroxidized. Necessary precautions are the employment of a solution sufficiently acid to prevent reversion to unoxidizable metatitanic acid and of peroxide of hydrogen free from all traces of fluorine compounds, which we often find in commercial samples. These prevent the appearance of the full color of the titanium peroxide and thus lead to false results.

[*To be concluded.*]

Committee on Science and the Arts.

The Taylor-White Process of Treating Tool-Steel.

[*Being the Report of the Committee on the Invention of Maunsel White and Fred W. Taylor. Sub-Committee : Charles Day, James Christie, Coleman Sellers, Arthur Falkenau, Wilfred Lewis.*]

Your Sub-Committee submits the following report on the Taylor-White process of treating tool-steel.

About three years ago an extensive series of experiments were undertaken at the Bethlehem Steel Works, by Messrs. Taylor & White, in order to determine the relative efficiency of various brands of tool-steel on the market at that time.

There are two distinct classes of tool-steel, namely, carbon and air or self-hardening. The later brand, the result of Mushet's work, has completely replaced the carbon steel for roughing, its comparative efficiency approximately being 1·5 to 1·0. Mushet discovered that by the addition of manganese and tungsten to tool-steel it maintained its cutting edge at much higher temperatures and consequently much higher speeds were possible. The general introduction of this steel did not, however, take place as rapidly as one would suppose, the manufacturers failing to appreciate the great economy realized by using it. In fact, very few of the shops that did use it obtained the greatest efficiency possible, as no knowledge of cutting speeds and feeds was at hand.

The object of the experiments above referred to was largely to obtain this data for different materials and to determine the tool best adapted to their work.

It was found that the results obtained from different tools made from the same steel varied greatly, and as the only way of accounting for it was by variations in the process of hardening, it was decided to make a thorough investigation along these lines.

Having decided upon a brand of steel, tools were forged and heated to different temperatures and then put in a lathe

and tested. It was found that those cooled from a very high temperature gave remarkable results far surpassing anything yet accomplished.

It must be understood at this point, that all air-hardening steel, manufactured up to this time, was hardened by heating to a cherry-red and either allowed to cool gradually or in a blast of air. Users were invariably cautioned against overheating, cherry-red being specified as the desired temperature.

The above tests marked the beginning of a most thorough series of experiments, the object being to determine the best chemical composition and temperature for treating. In carrying out the above experiments a 66-inch Bement-Miles lathe was belted to an Evans friction-cone countershaft, it in turn being geared to a 40 horse-power Westinghouse motor. By this means any desired speed could be obtained. A depth of cut of $\frac{3}{16}$ inch and feed of $\frac{1}{16}$ inch with a duration of test of twenty minutes was adopted as standard. Two hundred tons of forgings were cut up in carrying out this work, the total cost aggregating $100,000.

A review of the patent specifications may now be well in order that we understand exactly the claims made. Messrs. Taylor & White say in part: "Our invention relates to the manufacture of tools for cutting metals or similar uses where the tool is highly heated in performing its work, the object of our invention being to provide a tool capable of working at higher temperature, and consequently doing more work in a given time than the tools as heretofore made." The above statements make it very clear that the tool is adapted to *roughing work only*, and unless sufficient speed can be obtained, no gain in output can be had. We wish to make this point perfectly clear.

Again, on the first page of the patent papers (Pars. 65–90), we find a general statement of the invention which may be worth quoting: "Our invention is based on our discovery that, while it is true tools made of air-hardening steels all deteriorate at temperatures in excess of a bright cherry-red (though it must be understood, not all at the same temperature), it is also true that when air-hardening steels are

made with certain constituents in ascertained proportions this deterioration only prevails during a limited range of temperatures above the bright cherry-red; that is to say, from about 1,550° F. to about 1,700° F. (corresponding to a light-salmon color), and on our further discovery that above this range of temperature, which we will call the "breaking-down point," and from 1,725° F. up to a temperature at which the steel softens or crumbles when touched with a rod

LINK-BELT ENGINEERING COMPANY,
NICETOWN, PHILA.

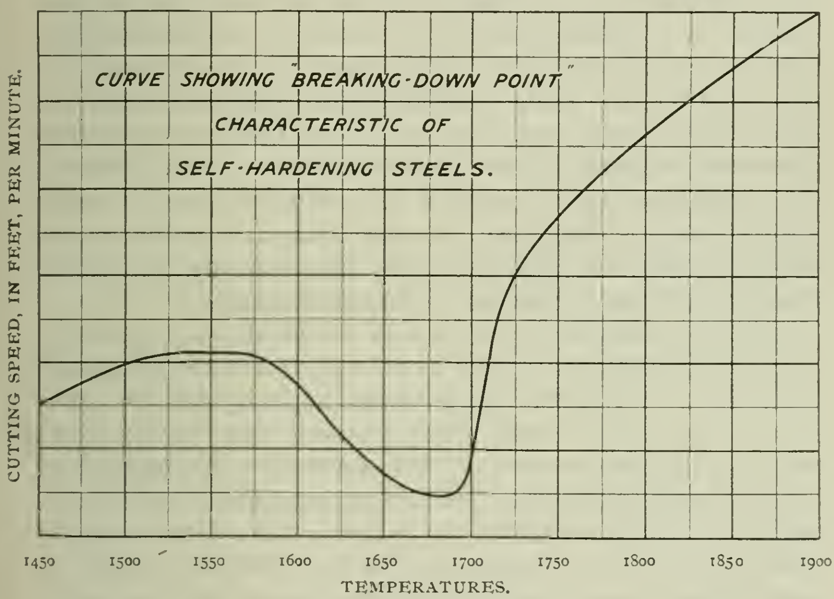


FIG. 1.

(approximately 1,900° or 2,000° F.) the efficiency of tools of such special steels; that is to say, their cutting speeds, and also their uniformity in efficiency, is greatly increased and largely so in proportion to the degree of heat to which they are raised. This is so much the case that their cutting speed may be stated to be from one and a half to two and a half times that of the tool heated as heretofore, to a temperature below the breaking-down point. The accompanying curve of temperature and cutting speed shows very

clearly in a graphical manner the principle of the Taylor-White discovery, and also the reason why a cherry-red was deemed best heretofore, as the curve falls off at this point.

How true the above statement of increased efficiency is, can be judged later when considering the experiments made recently by the Sub-Committee.

In order to obtain a suitable steel for the Taylor-White treatment it is necessary that it should be compounded with chromium in the proportion of at least one-half of 1 per cent., and another or other members of the commercially available members of the chromium group of metals in the proportion of at least 1 per cent.; that is to say, with either tungsten or molybdenum in the proportion of at least 1 per cent. They also state that materially better results are obtained in some cases by increasing these proportions. The relative value of the various members of the chromium group are carefully considered in the patent papers, and it is interesting to note that the percentage of carbon seems to have little or no effect on the results, steels containing from 85 C. to 200 C. having the same efficiency.

We naturally ask, what changes does the steel undergo when subjected to this high heat? and in answer will again quote from the patent papers, page 2, paragraph 50: "We do not feel able to state with certainty the chemical and molecular changes which occur in steels of this composition when heated above the breaking-down point, and to the high-heat characteristic of our process, but will mention as one characteristic change due to our treatment, that the tools after exposure to the high heat, shown by analysis, a *smaller* percentage of carbide of chromium than existed in the steels before such treatment, for example, in steels containing $1\frac{1}{2}$ per cent. chromium and $\frac{7}{10}$ per cent carbide of chromium, the tool after treatment contained but $\frac{2}{10}$ per cent. of carbide of chromium, and in steels containing $\frac{3}{4}$ per cent. of chromium and $\frac{9}{10}$ of carbide of chromium, the treated steel contained but $\frac{3}{10}$ per cent. of carbide of chromium.

Again, air-hardening steels of this composition, like air-hardening steels in general, possess in their normal condi-

tion the characteristically fine velvety grain when fractured. The higher range of temperature necessary in our treatment has a very noticeable tendency to change the structure of the metal and to give a non-velvety appearance and coarser grain, frequently interspersed with sparkling grains. " When treated with the higher heats and to obtain the best results, the steel of the tools shows under the microscope a distinctly large-grained structure, in many cases intercepted with austenite or microconstituent of steel discovered by Osmond, the chemical composition of which is unknown, and which, according to the best authorities, has never been met with in the industrial treatment of steel."

The question of cooling the tool is considered in detail, different methods being adopted for various duties. They may be in general stated, however, as follows: The tool is cooled rapidly from the high heat to a point below the breaking-down temperature in a lead bath, then slowly in the air or lime, etc., as the case may be. It is very essential that at no time the temperature should rise, as in such a case the tool would be seriously impaired. After the tool has cooled off, its efficiency is found to be further increased by subjecting it to what is termed the low heat for about ten minutes, this temperature ranging from 700° F. to 1,200° F. One of the chief claims made by Messrs. Taylor & White is the great uniformity obtained by their process, which makes it possible to run every tool to a very high efficiency. This uniformity is obtained by the apparatus employed, by means of which remarkably close temperatures can be ascertained. The tool, after being forged, is placed in a coke furnace, where it is heated gradually to a high heat, the latter being designated as the point at which the steel crumbles when tapped with a rod. As the tool is incandescent at this point, it is necessary that the operator wear colored glasses while testing for heat.

After heating, the tool is rapidly drawn from the furnace and plunged into a lead bath, which is maintained at a certain temperature by a very ingenuous method; a sketch may help to make this part of the process more clear. The cast-iron retort shown is heated from below by means of a coke

fire, the intensity of which may be increased at will by means of a blast of air. If the temperature rises too high, the closed pipe *P*, which has cold water circulating in it, can be lowered into the bath. The temperatures are determined as follows: From a lip in one side of the crucible is placed a pipe *T*, which projects into the lead bath. This pipe is enclosed in

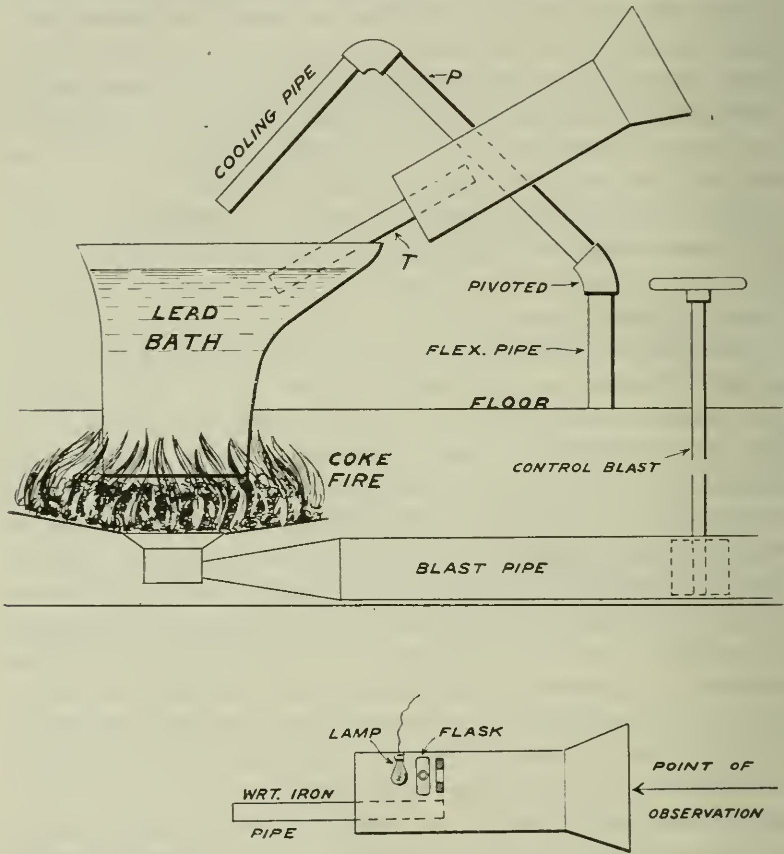


Fig. 8.

turn in a wooden tube blackened inside, also containing a flask of fluid lighted by an incandescent lamp in such a position that its color may be compared directly with the bath as seen through pipe *T*. Great care has been exercised in obtaining chemical ingredients for different temperatures that would be uniform, and of course the lamps must be

standarized and voltage kept constant by means of a rheostat. It must be thoroughly understood that it is in no way essential to use apparatus of this character to obtain a treated tool. In fact, your Committee has seen very good results obtained from tools treated in an ordinary smithshop fire and cooled in a blast of air. We do not feel, however, that the uniformity can be had by the latter method, and as it is this point that makes the treatment so valuable, we think that the great stress should be laid on the apparatus. The tools at Bethlehem are treated by laborers, who receive $1.35 per day. It might be well to mention at this point that in some cases where it is desirable to grind the tool before treating, a flux is used in order to prevent burning at the high heat.

In order to verify the statements made in the patent papers with regard to increased efficiency at high speeds, and to investigate the apparatus above referred to, your Committee visited the Bethlehem Steel Works on December 20 and 21 in 1901. Various brands of air-hardening steel were purchased and hardened in the presence of the Committee, according to the manufacturers' instructions. These tools were forwarded to the Bethlehem and ground to the standard angles as given below. The tests were primarily made out at Bethlehem on account of the experimental lathe above referred to, it being the only one where any desired speed could be obtained with sufficient power to pull the cut. Three different test-pieces were experimented on--two of steel and one of cast-iron. All the tools that were tested were brands that were on the market at the time the Taylor-White patents were granted.

Numerous tests have been made before and published, but none that we had access to showed the relative value of various tools in the true light; consequently we decided to run the tools at the same depth of cut and feed, varying the speed in order that each tool should last twenty minutes. It will be seen at once that an exhaustive test of this kind would take a very long time, as the speed must first be approximated many times before the right one can be obtained. The consequence was that the tests were not as

full as we had desired, but we feel they are sufficiently convincing for our purpose.

Tool-Steel Tested.	Date.	Exp. No.	Forging No.	Feed.	Depth of Cut.	Cutting Speed Aimed at.	Duration of Cut.	Average Cutting Speed Obtained.	Condition of Tool at End of Run.	Remarks.
				inch.	inch.					inch.
T.W.H. 2313	Dec. 19	1	7238C1	$\frac{1}{16}$	$\frac{3}{16}$	11	20	11	Fair	$5\frac{7}{8}$ travel
Mushet . . .	"	2	"	$\frac{1}{16}$	$\frac{3}{16}$	5	(*13½)	5	Point gone	$1\frac{15}{16}$ "
"	"	3	"	$\frac{1}{16}$	$\frac{3}{16}$	3½	(†12½)	3½	completely	1½ "
Sanderson .	"	4	"	$\frac{1}{16}$	$\frac{3}{16}$	3½	20	3½	gone	1⅞ "
Boreas	"	5	"	$\frac{1}{16}$	$\frac{3}{16}$	4½	20	4½	"	2 "
Mushet	"	15	"	$\frac{1}{16}$	$\frac{3}{16}$	3	4	3	"	
Raeburn .	"	17	"	$\frac{1}{16}$	$\frac{3}{16}$	3	20	3	fair	1¾ "
Mushet . . .	"	18	"	$\frac{1}{16}$	$\frac{3}{16}$	3	20	3	gone	1¾ "
T.W.M.E. 2836	Dec. 20	6	19788B1	$\frac{1}{16}$	$\frac{3}{16}$	140	20	140	good	39¾ "
Sanderson . .	"	8	"	$\frac{1}{16}$	$\frac{3}{16}$	72	20	72	fair	19⅜ "
Mushet .	"	9	"	$\frac{1}{16}$	$\frac{3}{16}$	72	1¾	72	gone	1¾ "
Boreas	"	10	"	$\frac{1}{16}$	$\frac{3}{16}$	72	6½	72	"	6⅜ "
Mushet	"	11	"	$\frac{1}{16}$	$\frac{3}{16}$	60	19	60	"	15¾ "
Sanderson .	"	17	"	$\frac{1}{16}$	$\frac{3}{16}$	82	19¼	82	"	22½ "
Benj. Atha . .	"	13	"	$\frac{1}{16}$	$\frac{3}{16}$	82	13	82	"	15¼ "
T.W.M.E. 2757	"	14	"	$\frac{1}{16}$	$\frac{3}{16}$	156	20	156	good	40⅛‡ "
T.W.B. 0·3 . .	"	19	1506A	$\frac{1}{16}$	$\frac{3}{16}$	70	20	70	gone	$16\frac{7}{16}$ "
Boreas . . .	"	20	"	$\frac{1}{16}$	$\frac{3}{16}$	55	20	55	good	12¾ "
"	"	21	"	$\frac{1}{16}$	$\frac{3}{16}$	60	3 8	—	gone	$2\frac{9}{16}$ "
Mushet	"	22	"	$\frac{1}{16}$	$\frac{3}{16}$	50	20	50	"	$11\frac{9}{16}$ "
Benj. Atha . .	"	23	"	$\frac{1}{16}$	$\frac{3}{16}$	50	20	50	good	11⅝ "
T.W.B. 0·3 . .	"	24	"	$\frac{1}{16}$	$\frac{3}{16}$	70	20	70	"	16½ "
Benj Atha . .	"	25	"	$\frac{1}{16}$	$\frac{3}{16}$	55	3½	—	gone	$2\frac{3}{16}$ "

* Examination of tool showed that it failed long before end of test.
† Point of tool red-hot for 13 minutes.
‡ Point of tool red-hot for 15 minutes.

CHEMICAL COMPOSITION OF ABOVE FORGINGS.

	Bar No. 7238 C′	Bar No. 19788 B′	No. 1506 A
Carbon . . .	·876	·105	Total 3·854; Graphite 2·948; Combined ·906
Manganese	·62	·36	·43
Silicon	·24	·025	·98

Phosphorous	·025	·023	·298
Sulphur	·028	·035	·055

ANGLES OF TOOLS TESTED.

	Hard Bar.	Soft Bar.	Cast-Iron.
Clearance	6°	6°	6°
Front rake	5°	8°	14°
Side rake	9°	12°	18°

The above table shows the data just as we obtained it, an explanation of forgings, numbers, etc., being given below. It must be understood that all the tools compared with the Taylor-White in these tests were tools that were on the market at the time of the invention. We will consider later various treatments that have come into existence since the Taylor-White patents were granted.

An examination of the tests on the 86° C. hammered forging shows that the relative efficiency of the treated tool and best untreated tool is 11 to 3 or more than 3·5 to 1, for the soft forging (10 carbon) 156 to 70 or 2·2 to 1, and for the cast iron 70 to 55 or slightly less than 1·3 to 1. These figures show that for steel the efficiency is much greater for hard forgings than for soft, but even in the latter case exceeds two to one, while as we might expect the saving on cast-iron is much less, being about $1\frac{1}{4}$ to 1. On hard castings, however, the gain is much more, often reaching 2 to 1, and on this account it is well adapted to certain work. In proof of the latter statement we might add that at the Link-Belt Engineering Company's Works, Nicetown, hard-sprocket wheels can be bored at more than double the speed with Taylor-White tools.

There were many points of interest in the above tests for any one who was not familiar with the operation of treated tools working on low-carbon steel. Reference to the table shows a cutting speed of 156 feet per minute, with $\frac{3}{16}$-inch depth of cut and $\frac{1}{16}$-inch feed. This tool was removing metal at the rate of 353 pounds per hour and was *red-hot* $\frac{5}{16}$ inch from the point. The color was distinctly visible in the daylight, no stronger proof being needed of the high heat at which these tools maintain their cutting edge. At the end of twenty minutes the edge of the tool was carefully

examined with a magnifying glass and found to be *perfect*. In fact, the original grinding-marks could still be detected; consequently, we see that the claims made by the inventors regarding increased efficiency for roughing work are just, so far as the brands of steel we compared are concerned. The importance of this discovery can scarcely be overestimated when we consider how its influence is felt in every establishment where cutting tools are used.

If the manufacturer is doing a large proportion of roughing, it may be the means of doubling his output, assuming that he has already been using the best-known steel. The discoveries of Messrs. Taylor & White, coming, as they did, at a most opportune time, have been an epoch in machine practice, and have simply proved again that scientific methods lead to much better results than guess-work. The great interest which their work awakened in the engineering world was largely due to Mr. Taylor's system of controling the men at Bethlehem Steel Works, which made it possible to run every machine to a much higher efficiency than has heretofore been thought of. We also feel that the Taylor-White steel has done more for a certain class of machine design than any other thing we can point to. It is no longer desirable to have close-speed regulation, etc., but absolutely essential if maximum output is desired. The entire problem has become one of scientific study instead of guess-work, and it is to such work as that followed out by Messrs. Taylor & White that we must look in the future.

In another part of this report reference was made to treatments which have been put on the market since the Taylor-White patents were issued. Several manufacturers of tool-steel claim to have a tool that gives results quite equal to the Taylor-White, and it was our desire to have such tools entered in the above test.

As several of the manufacturers object to making them at the Bethlehem Steel Works, it was deemed best to postpone these trials until a later date, when they can be made at the Link-Belt Engineering Company on a lathe especially adapted to this work and which they expect to have in oper-

ation in a few weeks. If such a series of tests are made it will, of course, be necessary to prove that the various tools do not infringe the patents we are considering.

In conclusion, your sub-committee takes pleasure in recommending the award of the Elliott-Cresson Medal to Messrs. Taylor & White for the discovery and development of a method of treating a certain composition of tool-steel which has made it possible to largely increase the output of machines doing roughing work.

Adopted April 11, 1902.

Attest: WM. H. WAHL, *Secretary.*

ABRAM S. HEWITT.

It is given to few men to do so many things in this world—and to do them so well—as Abram S. Hewitt. An engineer of marked ability; a shrewd and far-sighted business man; a manufacturer who in fifty years never had a strike to contend with; the practical head of a great educational institution; the executive of a great city, the integrity of whose motives was never questioned; a legislator whose opinions on public questions were always heard with respect; above all, a citizen who was ever ready to aid in any movement in the public interest; he leaves a record which must command universal respect, and which may well be studied by younger men. He fully earned the title given him by one of his friends—the "first citizen of New York."—*Electrical World.*

NEW CHEMICAL COMPOUND.

The aluminate of magnesium is a new product which M. Emile Dufour has succeeded in obtaining. An account of the method used has been presented to the Académie des Sciences. In an electric furnace, using a powerful arc of 1,000 amperes and 60 volts, is heated a mixture of 100 parts of alumina and 230 of oxide of manganese, the heat lasting for three minutes. In this way is obtained a porous mass of a brownish-black color, with a metallic reflection. When broken, it presents an irregular surface which is of a fine light-green color and shows a number of geodes of a brown color, lined with brilliant crystals of the octahedral system. To separate the compound, the material is broken and treated with hydrochloric acid; gases are given off and the liquid takes a brown tint, which changes gradually to a light yellow. A crystalline deposit is thus obtained, which is still further purified and analyzed; its composition corresponds to the formula Al_2O_4Mn. The aluminate of magnesium has the form of small transparent crystals of a light yellow color, having the appearance of octahedra, but somewhat modified on the angles. Their density at 20° C. is 4·12. This body is harder than quartz, and its powder is of a light-yellow color. It is quite stable under ordinary conditions, but oxidizes easily when heated in air. At a red heat it

gradually changes color to a dark brown, becoming somewhat lighter upon cooling. In oxygen this oxidation, which was before only superficial, is more rapid and takes place below a red heat. Fluorine attacks it with incandescence at a red heat, but it is not acted upon by bromine, iodine or sulphur. It is insoluble in hydrochloric acid, but is easily attacked by nitric and hydrofluoric acids, and especially by sulphuric acid. Oxidizing agents, such as chlorate and nitrate of potash in fusion, and also the alkaline oxides or carbonates, decompose it easily.—*Scientific American.*

FRESH INTEREST IN TIN MINING.

The one metal absolutely necessary in the production of staple manufactures which has not been produced in this country to any extent is tin. Attempts have been made quite frequently to develop the deposits of this metal which have been discovered in various sections of the United States, but in almost every instance the deposits have either proved too lean to work satisfactorily, or the companies undertaking the problem of conducting operations have not had sufficient capital. It is interesting to note that renewed attention is now being displayed in this direction. Companies have been formed for operating in South Dakota and Southern California, and they are announcing with confidence that they have not only satisfactory deposits of tin ore, but that sufficient capital has been secured to enable operations to be successfully prosecuted. It is to be hoped that the expectations entertained by these companies will be realized, and that this year may see tin produced on a commercial scale in the United States. This country is the largest consumer of tin in the world, and it would be decidedly beneficial to the consuming interests if this essential metal could be produced at home.—*Iron Age.*

CAR AND LOCOMOTIVE STATISTICS FOR 1902.

Returns received direct from practically every locomotive and car-building plant in the country show that approximately 164,547 cars have been built in 1902, including cars for use on elevated railroads, but exclusive of street and other electric cars. This is considerably the largest record which has ever been made in the country and exceeds by 25,542 cars the output for 1901. These figures do not include cars built by railroads at their own shops. Of the cars recorded approximately 162,599 are for freight service and 1,948 for passenger service; 161,747 are for domestic use and 2,800 are for export. In 1901 the total number of cars built was 144,267, which exceeded by 20,161 the recorded output for the year 1900. The 1901 figures included also 5,262 street cars. Almost all of the figures for both 1902 and 1901 are official. The proportion of steel cars and cars with steel underframes to wooden cars will be published in a subsequent issue. It may be interesting also to note that 5,571 cars were built during the year by three firms in Canada.

During the year 4,070 locomotives were built at the various locomotive plants in the country, against 3,384 in 1901. This figure is official throughout and required no estimating. The number for 1902 includes seventy-four electric locomotives. The real meaning of this figure is perhaps best realized by calculating the expenditure involved, which would be nearly $48,000,000. —*Railroad Gazette.*

PHYSICAL SECTION.

Stated Meeting, held February 27, 1901.

On the Mathematical Theory of the Geometric Chuck.

BY E. A. PARTRIDGE, Ph.D.

The cycloid, so important in the history of mathematics, was invented by Galileo in 1590 and named by him as early as 1598. The great mathematicians of the seventeenth century threw all their energy into the task of discovering its properties.

To determine its area, Galileo cut out a cycloid and its generating circle and weighed them. He drew the conclusion that the cycloid has an area very nearly three times the area of the generating circle. This story is given by Torricelli in a letter to Mensenne written in 1643.

In 1658 Pascal wrote a history of the roulette, as the cycloid was called in France. In this work he attributed the invention of the curve to Mensenne and accused Torricelli of intentionally claiming for himself the discovery of results that had previously been obtained by Roberval. A careful study of the whole question has lead Cantor to the conclusion that the charges against Torricelli were erroneous. Pascal contributed greatly to the work of unraveling the properties of the cycloid. Roberval and Wallis each wrote treatises on it, and Descartes, Fermat, Huygens and Wren made important contributions to the growing mass of information concerning this marvelously attractive curve, which, as Chasles says, is connected with nearly all the advances made in mathematics during the seventeenth century.

Curves, such as are considered in this paper, were first conceived by Albrecht Dürer who, in 1525, described what he called the "Spinnlinie," a curve generated by a point moving in a circle about a point itself moving in a circle. He was the first to figure epicyclic curves. More complicated curves than those just described were also conceived by Dürer. He considers curves generated by a point moving

in a circle about a point moving in a circle about a point moving in a circle; in other words, curves resulting from the superposition of several circular motions. They were probably considered by him on account of their ornamental character. However, as Mr. Procter points out, the invention of epicyclic curves should be attributed to the ancient astronomers and particularly to Ptolemy who used some of the properties of such curves in explaining the apparent motions of the moon and planets. But Ptolemy nowhere states anything concerning the shape of an epicyclic curve.

The application of the epicycloid in the construction of the teeth of gear wheels has been ascribed to both Desargues and Roemer.

The mechanical description of epicyclic curves was first accomplished by Soardi, an Italian count, by means of an instrument which he called the "Geometric Pen." This geometric pen was described by him in a work, the substance of the title of which is "On a new instrument for drawing many curves both old and new, which can serve for speculative and practical geometry." This work appeared in 1752. The geometric pen seems to have been limited to drawing curves resulting from the composition of two circular motions. About 1817 Ibbetson devised what he called a geometric chuck. This instrument was made to be used in connection with a lathe.

Perigal and others have from time to time introduced improvements in the construction and arrangement of the chuck. The action of the machine has been carefully studied by Perigal, but in a purely mechanical way. So far as I am aware, no mathematical treatment of the geometric chuck has hitherto appeared.

The geometric chuck is an apparatus which traces curves that result from the superposition of circular motions. In this description of the chuck all mechanical details will be omitted, only the results obtained by the action of its component parts being attended to.

The action of the chuck is as follows:

A plane AB, *Fig. A*, rotates about a fixed center A, a second plane CC' rotates about the center B which is at the same

time rotating about A. A third plane DD' rotates about the center C which is rotating about B. A fourth plane EE' rotates about D which is at the same time rotating about C. A fifth plane GG' rotates about E which is at the same time rotating about D. To the fifth plane GG' is fastened a piece of paper upon which the pen at F traces a curve. Ordinarily the pen is fixed, but it can be given a circular or simple harmonic motion, thereby still further complicating the figure.

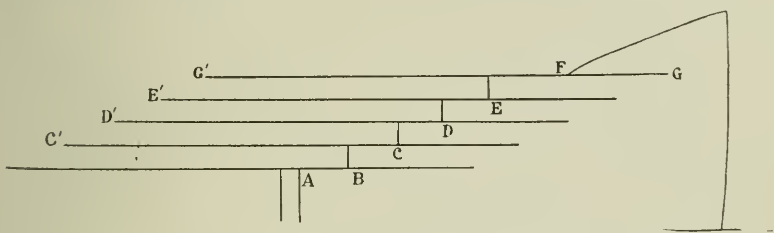


FIG. A.

The above is the actual arrangement.

The distances between the several centers of rotation, viz., AB, BC, CD, DE and AF are all adjustable, as are also the relative angular velocities. These latter can be direct or retrograde. Since the curve is traced by the fixed pen and movable paper the relation between the tracing point and the center A is different from the relations between the other centers of rotation; it is necessary for the symmetry of the mathematical treatment that the relation should be made the same.

The latter requisite is accomplished by inverting the chuck in the following fashion. This is the actual arrangement of the geometric pen:

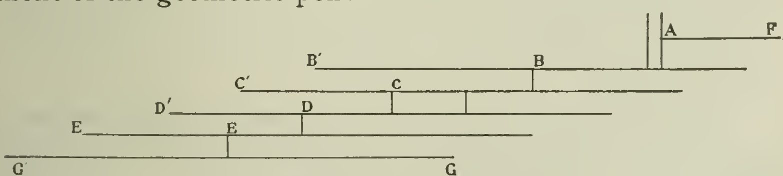


FIG. B.

G' G, *Fig. B*, is regarded as fixed. The plane EE' rotates about E, the plane DD', about the point D, CC' about C, BB'

about B, the line AF about the point A. The curve traced by F is the same as the curve traced on the movable paper by the fixed pen [F (*Fig. A*)] in the actual arrangement.

A method of approach particularly adapted for mathematical treatment is the following:

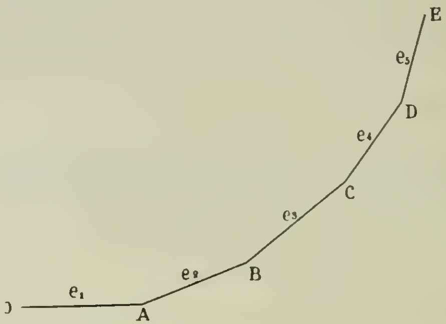


Fig. C.

O, *Fig. C*, is a fixed center round which A revolves carrying B, C, D and E, at the same time as A is revolving about O, B is revolving about A and C about B, D about C, E about D. The path traced by E is a geometric chuck curve.

The following is the notation adopted:

$$e_1 = OA$$
$$e_2 = AB$$
$$e_3 = BC$$
$$e_4 = CD$$
$$e_5 = DE$$

All adjustable but constant during the tracing of any curve considered in this paper.

w is the angular velocity of an auxiliary point moving in a circle, the curve traced by the chuck will close when $wt = 2\pi$. $t =$ time.

$a_1 w$ is the angular velocity of A about O with reference to a fixed line on the paper. $a_1 = 1$ unless some of the relative angular velocities have fractional values. If this be the case a_1 is the least number that will make all the coefficients of w integers.

v_1 is the ratio between the angular velocity B about A

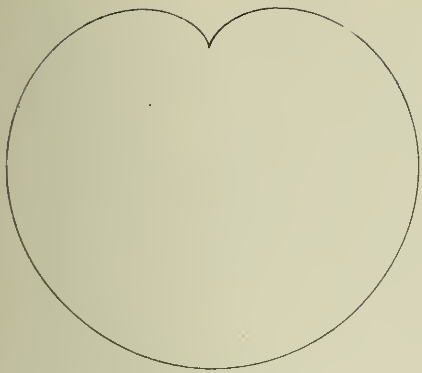


FIG. 1.

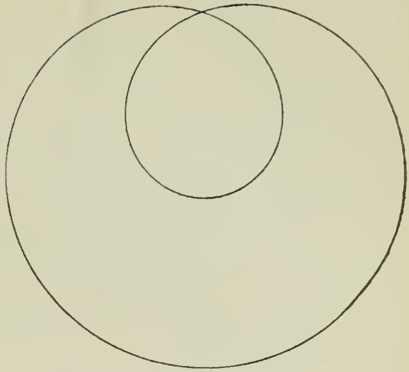


FIG. 2.

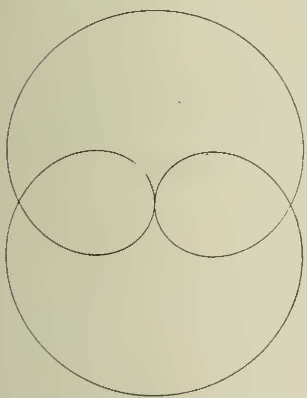


FIG. 3.

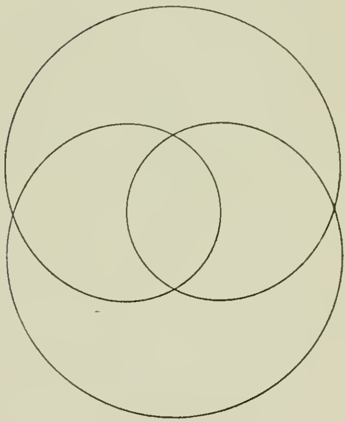


FIG. 4.

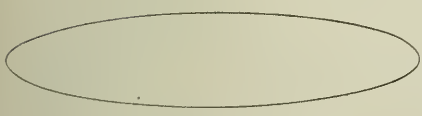


FIG. 5.

FIG. 6.

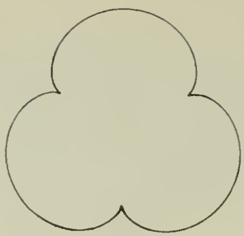


FIG. 7.

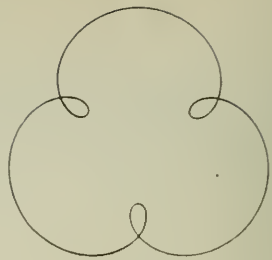


FIG. 8.

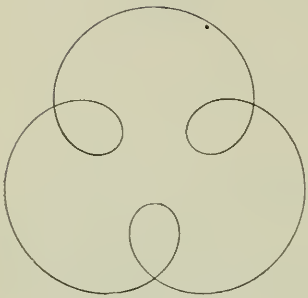


FIG. 9.

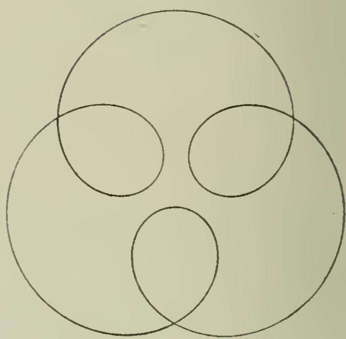


FIG. 10.

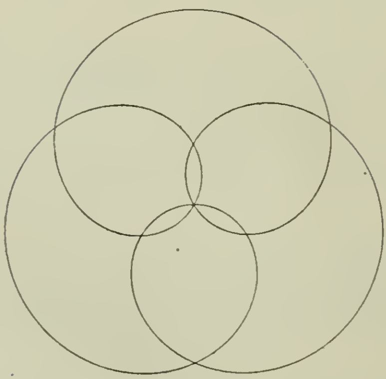


FIG. 11.

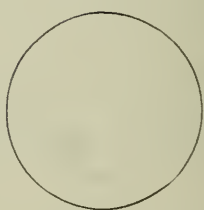


FIG. 12.

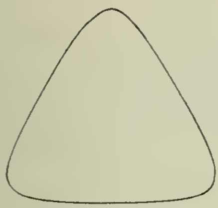


Fig. 13.

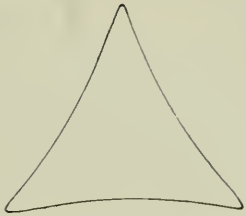


Fig. 14.

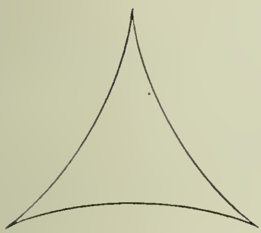


Fig. 15.

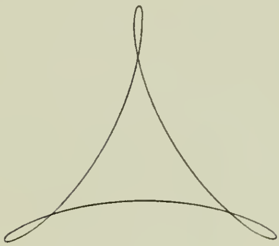


Fig. 16.

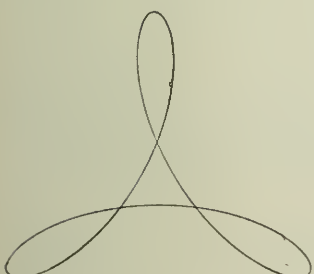


Fig. 17.

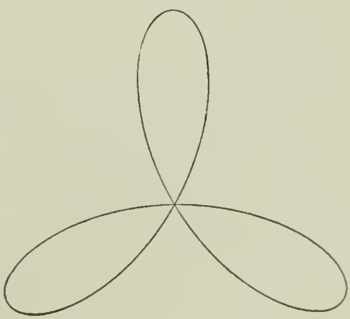


Fig. 18.

with relation to the line OA, to the angular velocity of A about O,

$a_2 w = (a_1 + a_1 v_1) w$. That is, $a_2 w$ is the angular velocity of the line AB with reference to the fixed line.

v_2 is the ratio between the angular velocity of C about B relative to the line AB, to the angular velocity of B about A relative to the line OA.

$a_3 w = (a_1 + a_1 v_1 + a_1 v_1 v_2) w$ is the angular velocity of the line BC with relation to the fixed line.

v_3 is the ratio of the angular velocity of D relative to BC to the angular velocity of C relative to AB.

$a_4 w = (a_1 + a_1 v_1 + a_1 v_1 v_2 + a_1 v_1 v_2 v_3) w$ is the angular velocity of CD relative to fixed line.

v_4 is the ratio of the angular velocity of E relative to CD to the angular velocity of D relative to BC.

$a_5 w = (a_1 + a_1 v_1 + a_1 v_1 v_2 + a_1 v_1 v_2 v_3 + a_1 v_1 v_2 v_3 v_4) w$ is the angular velocity of DE relative to fixed line.

$p_1 =$ angle between e_1 and fixed line at $t = O$.

$p_1 =$ angle between e_2 and e_1 when $t = O$.

By choosing the proper direction for the fixed line, p_1 and p_2 may always be made $= O$.

$p_3 =$ angle between e_3 and e_2 when $t = O$

$p_4 =$ " " e_4 and e_3 " $t = O$

$p_5 =$ " " e_5 and e_4 " $t = O$

Concerning these quantities the following remarks are to be made:

e_1, e_2, e_3, e_4, e_5, are always positive magnitudes, and are adjustable. They can take all values between 0 and 2 inches in this particular chuck.

w and a_1 are always positive.

v_1, v_2, v_3, v_4, may be positive or negative. They are adjustable, and can take integral or rational fractional values.

p_3, p_4, p_5, may be positive or negative. They are adjustable between 0° and 360°.

[*To be concluded.*]

Notes and Comments.

ACTINIUM, POLONIUM AND RADIUM.

In 1898 Madame P. Curie discovered in pitch blende and chalcolyte (two ores of uranium) a new metal—polonium. Subsequently, M. Curie, Madame Curie and M. Bémont determined another element—radium. In 1899, M. Debienne characterized a third simple body—actinium. The extraction of these metals is not only quite delicate, but long and costly To give an idea, it is sufficient to say that about 0·10 gram of radium chloride is found per ton of ore; that is to say, the residue of the extraction of uranium.

Radium resembles barium closely; its high atomic weight, 175, assigns for it a place in the elements of high atomicity in the Mendéelef tables. Polonium resembles bismuth closely and is precipitated by hydrogen sulphide. Actinium is precipitated by ammonium sulph hydrate and is similar to thorium.

These new elements possess extremely interesting properties, among which is that of emitting rays similar to those discovered by Professor Roentgen in the light of the Crookes tubes.

In 1896, M. H Becquerel, in studying phosphorescent bodies, remarked that the salts of uranium and the double salts of uranyl and of sodium, or potassium, emit special radiations having great similarity to the X-rays. These have been called Becquerel rays. The three new metals emit Becquerel rays in enormous quantity, approximately 100,000 times greater than uranium. It seems, also, that uranium owes its property only to the presence of traces of actinium.

The radiations of radium, like cathodic rays, are deviated partly by the magnetic field. Another part is not deviated like the X-rays. The deviable rays are charged negatively.

These rays are not reflected nor refracted nor polarized, which is contrary to the existing conception of all vibratory movements. They discharge electrized bodies very rapidly, even through a covering of glass. The dust of the radio-active bodies renders all the objects of the laboratory radio-active. No electric measuring of precision can be done in their presence, the insulators becoming good conductors. It seems that the radio-activity is an atomic property of these bodies; that is, a property connected with the matter itself and not capable of being destroyed, neither by change of physical state nor by chemical transformation. Certain bodies—zinc, tin, aluminium, brass, lead, paper, may acquire radio-activity by induction.

The induced activity increases with the time of exposure and is lost gradually.

Polonium, actinium and radium so act on certain substances as to render them fluorescent, as zinc sulphides, earthy alkaline and alkaline substances, uranium salts, the diamond, blende, paper, glass, cotton.

Radium possesses the property of being spontaneously luminous. This luminosity is readily observed in semi-darkness, and the light emitted may be sufficient to allow of distinguishing written characters. The most curious fact

is that the light emanates from the whole mass, contrary to what takes place in the case of ordinary phosphorescent bodies, which shine only on the surface previously impressed by the light. In moisture the luminosity is diminished, but on drying it reappears in all its intensity. It is continuous, or at least appears to be so, for at the end of a year it is not sensibly diminished.

Radiferous salts have very interesting chemical and photographic properties, due undoubtedly to their radio-activity. They convert oxygen into ozone, and in general act as powerful oxidants or exciters of oxidation. Thus glass and porcelain, with oxidation of manganese, are colored violet under their influence. The chlorides of sodium and of potassium are colored strongly, the latter a deep blue. The rays exert an energetic action on photographic plates, even through opaque bodies, and produce radiographs—less distinct, however, than those of the X-rays.

The applications of these substances may be numerous, provided they can be prepared in appreciable quantity and at lower cost.

Luminous indications might be made on the dials of watches and compasses. The physiological action is not less important. As slow producers of electricity the salts are indicated in the treatment of neuralgia. By application to the temples, and acting on the retina through the flesh, they may serve for diagnosing paralysis of the optic nerve.

Radium was employed in the expedition of M. Paulsen in Iceland for taking the electric tension of the atmosphere, replacing apparatus, complicated and less easy of transportation.

The curious properties of these new metals are for the most part opposed to all accepted mechanical theories, physical and chemical, for they appear to be *spontaneous producers* of light and electricity, in a word, of energy. Now, it cannot be admitted that a body can produce energy indefinitely, however small the production, without borrowing from external sources, and without losing from its mass, and yet this appears to be the case with the three new metals.

According to the measuring of M. and Mme. Curie, the radiating energy is a ten-millionth part of a watt, or expressed in the displacement of matter, about one milligram in a thousand million years.

To reconcile these phenomena with the data of science, different hypotheses have been applied. Thus M. G. Le Bon holds that the energy proceeds from very mobile chemical reactions which may take place successively a great number of times in a very short period, under the influence of simple causes, such as slight variations of temperature. This explanation is perhaps premature, for the knowledge of these bodies is very limited, and nothing yet supports the theory. Is the source of this energy external? It may be supposed that space and material bodies are penetrated with rays of a nature yet unknown and capable of reacting on radio-active substances, so as to produce a secondary emission, manifesting itself in the observed phenomena. On the other hand, it is difficult to imagine electric conductibility in the absence of every material particle; and as these rays are conductors, it may be supposed that there is an ultimate form of very attenuated matter, which these radio-active bodies may be able to emit indefinitely without losing noticeably from their mass. However it may be, the spontaneity of the radiation remains an enigma, a subject of profound astonishment. There is ground for believing

that the discovery of these bodies marks a new stage in the grand history of science, and that it supports the hypothesis of the unity of matter, which has commanded the attention of philosophers for twenty-five hundred years. It is a new step toward the light, and a glimpse may be caught of the moment when the darkness which still envelops so many vast and difficult questions shall be entirely dissipated. Science is yet in its crudest manifestations, and our minds are scarcely trained to grasp the fundamental phenomena which incessant researches are gradually unveiling.—*Scientific Amer. Suppl.*, from the *Revue Chimie Industrielle.*

Book Notices.

Encyclopédié Scientifique des Aide-Mémoire. Librairie Gauthier-Villars, Paris, France.

The following volumes of this encyclopedia have appeared since the last notice of the publication in the *Journal.* Each volume is complete in itself, and the series, which has now reached extensive proportions, embraces nearly the entire field of the applied sciences.

Rabaté (Edmond), Ingénieur-agronome, Professeur spécial d'Agriculture.—L'Industrie des résines. Petit in-8, avec 38 figures.

Defays (J.) et *Pillet* (H.), Ingénieurs civils, Lauréats de la Société industrielle du nord de la France.—Etude pratique sur les differents systèmes d'éclairage. *Gaz. acétylène, pétrole, alcool, électricité.* Petit in-8.

Morel (Marie-Auguste), Ingénieur, ancien élève de l'Ecole des Ponts et Chaussées, licencié ès sciences mathématiques et ès sciences physiques.—Le ciment armé et ses applications. Petit in-8° avec 100 figures. (Broché. 2 fr. 50c. Cartonné, 3 fr.) W.

A Text-Book of Physics. By J. H. Poynting, Sc.D., F.R.S., and J. J. Thomson, M.A., F.R.S., etc. Properties of Matter. London: Charles Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Company. 8vo, vi + 228 pp. (Price, $2.75.)

This volume constitutes properly the first of a series forming a text-book on physics, which is being prepared by these well-known authors.

The present volume treats of the subjects of weight, mass, gravitation and those properties of matter which relate chiefly to change of form, as electricity, fluid viscidity, surface tension, diffusion and solution. W.

Specielle Elektrochemie. Von Dr. H. Danneal. Privat-docent für physikalische Chemie u. Elektrochemie an der k. techn. Hochschule zu Aachen. Lieferung I (large 8vo, pp. 80). Halle a. S. Verlag von Wm. Knapp. 1903. (Price, 3 marks.)

Elektromagnetische Aufbereitung. Von F. Langguth, Bergingenieur. (Large 8vo, pp. 64.) Halle a. S. Verlag von Wm. Knapp. (Price, 3 marks.)

The above-named volumes constitute the earliest contributions to an extensive "Handbuch der Elektrochemie," which is in course of publication by the house of Knapp, under the editorial supervision of such well-known experts as Borchers, Nernst and others.

The work of Danneal is devoted to the special electrochemistry of the elements and inorganic compounds; their production by electrochemical methods and their electrolysis.

Longguth's work is an interesting contribution to the history and application of the methods of magnetic separation and concentration of ores.

W.

Franklin Institute.

[*Proceedings of the Annual Meeting held Wednesday, January 21, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 21, 1903.

Vice-President WASHINGTON JONES in the chair.

Present, 210 members and visitors.

The annual election held this day resulted as follows:

For President	(to serve one year)	JOHN BIRKINBINE.
" *Vice-President*	(" three years)	THEO. D. RAND.
" *Secretary*	(" one year)	WM. H. WAHL.
" *Treasurer*	(" ")	SAMUEL SARTAIN.
" *Auditor*	(" three years)	W. O. GRIGGS.

For *Managers* (to serve three years).

CYRUS BORGNER,
JAMES CHRISTIE,
F. L. GARRISON,
H. W. JAYNE,
JAWOOD LUKENS,
LAWRENCE T. PAUL,
HORACE PETTIT,
OTTO C. WOLF.

(To serve for two years.)

CHARLES LONGSTRETH,
WALTON CLARK,
LOUIS E. LEVY.

(To serve for one year.)

WALTER WOOD.

For *Members of the Committee on Science and the Arts* (to serve three years).

H. F. COLVIN,
THOMAS P. CONARD,
GEO. S. CULLEN,
CHARLES DAY,
ARTHUR FALKENAU,
J. M. HARTMAN,
C. C. HEYL,
H. R. HEYL,
GEO. A. HOADLEY,
H. F. KELLER,
LOUIS E. LEVY,
TINIUS OLSEN,
LUCIEN E. PICOLET,
CHAS. E. RONALDSON,
CLAYTON W. PIKE,
SAMUEL P. SADTLER,
HENRY LEFFMANN,
W. N. JENNINGS,
ERNEST M. WHITE,
RICH'D L. HUMPHREY.

(To serve for two years.)

KERN DODGE,
E. GOLDSMITH,
WERNER KAUFFMANN,
JESSE PAWLING, JR.,
FRANK ROSELLE.

(To serve for one year.)

ROBERT H. BRADBURY, J. W. RIDPATH,
WM. O. GRIGGS, CHAS. A. RUTTER,
URBANE C. WANNER.

The annual report of the Board of Managers, with appendices embracing the annual reports of the Sections and of the various Standing Committees was presented, and is hereto appended.

Prof. Joseph W. Richards, of Lehigh University, presented a communication, illustrated by specimens and lantern photographs, on the "Aluminum Industry," with particular reference to the contributions of Mr. Chas. M. Hall.

Mr. E. E. Taylor, M.E., of Boston, read a paper describing the "Under-Feed Mechanical Stoking of Steam Generators," with special reference to the Jones Under-Feed Stoker. The speaker illustrated the subject freely with the aid of the lantern. The paper was discussed by a number of members, and the invention described was referred to the Committee on Science and the Arts for investigation and report.

A communication by Mr. H. Armor Ward, on the "Brazing of Iron Castings," was postponed until the next stated meeting on account of the lateness of the evening. Adjourned,

WM. H. WAHL. *Secretary.*

ANNUAL REPORT OF THE BOARD OF MANAGERS OF THE FRANKLIN INSTITUTE FOR THE YEAR 1902.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 17, 1903.

To the Members of the Franklin Institute:

In presenting its report for the year 1902, the Board of Managers of the Franklin Institute congratulates the members upon the determination evinced, by personal sacrifice, to maintain the work of the organization, which for nearly four-score years has been a leader in scientific progress.

An increase of the annual dues was often presented to the management, and as often discouraged, to exploit some other suggested method of bettering the financial condition of the Institute.

The Board, while realizing that the Institute offered its members in numerous instructive meetings, discussions and lectures, and in unexcelled library privileges, more than any other technical or semi-technical society, hesitated to recommend an increase of annual dues, equal to those charged by other organizations, until all other means had been tried.

For many years the income of the Institute has been insufficient to support its work properly, and assistance was obtained from exhibitions to supplement the income. But although the Institute originated industrial exhibitions in America, and held numerous successful displays, the magnitude of such functions at the present time involves a financial risk which the Institute cannot assume, and the amended charter requires that all special incomes pass to the Trustees for investment, the interest on which only can be applied to current expenses.

The Institute, bearing the honored name of Franklin is, unfortunately, considered as being a beneficiary of the noted philosopher, whereas not one dollar of Franklin's money came to the Institute.

The organization was perfected years after Franklin's death, and the name was selected because of a desire to honor Benjamin Franklin. It, however, received no benefit from funds resulting from Franklin's investments. In fact, the Institute's small endowment is made up of a number of bequests and gratuities, and the funds at present in the Trustees' hands aggregate only about $60,000.

If such invested funds were sufficient to produce annually a sum which, by supplementing the dues, would properly maintain the work, the financing would be a simple problem. But with a small endowment, most of which is limited in its application and low interest rate, the Institute must rely mainly upon the membership to sustain its work. Consequently, the Board, after mature consideration, recommended to the members a change in the by-law increasing the annual dues, which change was adopted by the Institute after full discussion.

Recognizing the interest thus shown by the members, a fund was raised to make the advanced dues immediately effective by paying all floating indebtedness; and the Board can, for the first time in many years, state that the Institute commences the year free of all indebtedness, except the fund above mentioned, which bears no interest and is an advance from those interested in the organization, which will be repaid from increased revenue, and except the mortgage made to the Trustees to pay for fire-proof library facilities, which is being annually reduced.

As the increase of dues took effect in October last, its permanent effect cannot be noted; but it is gratifying to report that a material increase in income is assured, and that the number of resignations which can be attributable to the augmented dues is less than was expected. Undoubtedly, most of the members have not measured the value of the Franklin Institute merely by the personal use they make of it, but rather by the service it renders the scientific world.

With its record of splendid achievements, the Franklin Institute deserves consideration from some who have surplus wealth to dispense, and it is the hope of your Board that such recognition will be accorded it as will permit of enlarging its field of work, and of carrying forward important investigations. But with the support of its present membership at the increased dues, the functions of the Institute, as now attempted, can be carried on and the expenses met, demonstrating a determination for self-help which should command recognition from others.

Appreciating the interest evidenced by the members in voluntarily increasing the annual dues, the Board of Managers is endeavoring to add to the value of membership by more closely limiting the privileges to non-members. This is not, or will not be done, to restrict the general usefulness of the organization, but to protect the Institute from those who abused privileges for which they made no return. The Board considers that the library, the lecture courses and other privileges, primarily belong to the members of the Franklin Institute, and its desire is to make this manifest, without in any way limiting the service which should be rendered the public.

Changing conditions demanded, and will continue to demand of the Franklin Institute, modifications in its detailed work. Although it has done pioneer service in establishing technical libraries and publications, scientific and popular discussions, and lecture courses presenting demonstrations of inventions and processes, etc., these valuable features have been copied by various junior organizations, some having liberal endowments, and to maintain its position of pre-eminence demands larger annual expenditures. The increased number of publications requires liberal appropriation to maintain a standard reference library of technical literature, and numerous lecture courses of a popular character require that the Franklin Institute present to its members the best, and the best costs money.

Papers and discussions at conventions of engineering and kindred societies require that the wide field attempted by the Institute be covered by superior papers and discussions at the meetings of the Institute and its Sections.

It has developed and should maintain a special work, much of which is not, or will not be accomplished by other societies or the technical press; but to maintain this work means that the Institute can keep in the van only at a continually increasing cost for maintenance.

That the above is being carried out with credit to the Institute is evidenced by the special reports of its Sections and Committees.

All parts of the Institute building are used for its library, schools, lectures, etc., and the congested condition of some portions emphasize the necessity for a new building.

In the work of the Committee on Science and the Arts, the Franklin Institute stands alone, and its medals and awards are eagerly sought for. Of the 108 cases before this Committee, fifty-two were disposed of and twenty-two medals, or awards, allotted. The gratuitous service which members of the Franklin Institute render through this Committee, to inventors and others, is of incalculable value, and the thoroughness of the investigations, and the equity of the awards, are evidenced by the small number of protests made. Errors have been or will be committed, but the safeguards thrown about the investigations and discussions, and the opportunity given for protest before an award is effective, minimize the risk of this important service, rendered without demand or expectation of return.

The demands on the members have been so great that, upon the recommendation of the Committee on Science and the Arts, its number was increased to sixty, by amendment to the by-laws.

The Board desires to express its recognition of the unselfish work of this Committee and of other Committees of the Institute.

The programs of monthly meetings prepared by the committee in charge have demonstrated the necessity of increased accommodation in our lecture-room, and improved facilities for demonstration and the work of the various sections has also emphasized this deficiency. It is regrettable that papers of such value, and discussions of such importance, must of necessity be prevented under existing disadvantages, or that the Committee on Instruction needs seek accommodations for those who attend its popular lecture courses elsewhere than in the Institute building.

Special attention is directed to the increased attendance reported in the night-schools of the Institute. Six hundred and thirty-nine young men, most

of them employed during the day, sought the privileges offered by the Franklin Institute to advance themselves, and for five nights during the fall and winter the Institute aids these worthy young men, who crowd our limited space to reach a higher and wider field than their present vocation offers.

Three hundred and eighty of these devoted their time to the drawing-school; 134 studied machine design; and our latest effort, the School of Naval Architecture, has 125 enrolled as students. Among these are undoubtedly some who, in future years, will achieve renown which may be credited largely to the facilities which the Franklin Institute has so persistently offered to those who wish to help themselves.

The report of the Library Committee shows a gratifying increase in additions, but repeats its complaint that the funds available are insufficient to properly care for our priceless library, or to add all which the Committee considers desirable.

Realizing the great value of the library, the Board of Managers is desirous of adding to this, and preserving the collection which could not to-day be duplicated.

With sorrow we report that two members of the Board of Trustees died during the year—Mr. Joseph M. Wilson, who for ten years served as President, and Mr. Enoch Lewis, who has for many years been associated with the Institute work. Also Mr. Stacy Reeves, whose active interest in housing our library demonstrated his loyalty to the Institute, was removed from us by death.

Suitable memorials of our departed co-laborers were adopted by the Board and the Institute. By order of the Board.

(Signed) JOHN BIRKINBINE,
President.

APPENDICES.

FINANCIAL STATEMENT FOR THE YEAR 1902.

Balance on hand January 1, 1902	$1,049 96
Receipts	26,614 73
	27,664 69
Payments	27,315 93
Balance	$348 76

REPORT OF THE COMMITTEE ON INSTRUCTION FOR THE YEAR 1902.

To the Members of the Institute.

GENTLEMEN: The Committee on Instruction has nothing to add to its report of the previous year in respect of the popular scientific lecture courses, which have been continued as in previous years in conjunction with the Central Branch of the Young Men's Christian Association. The policy of reserving admittance to these lectures exclusively to the members of the two societies, has caused a considerable decrease in the attendance as compared

with that of former years, but the Committee anticipates that this will be largely overcome by permitting the members of the two societies to receive a limited number of admission tickets for distribution to friends.

The services of lecturers, as heretofore, have been given gratuitously, and the thanks of the Institute are due all who have contributed to this branch of its work.

With reference to the operations of the schools, the Committee was able in its previous report to note a substantial increase in the number of pupils. The year 1902 exhibits even more gratifying evidence of improvement, as the following figures will disclose:

	1901.	1902.	Increase.
Drawing School	299	380	81
School of Machine Design	80	134	54
School of Naval Architecture	97—476	125—639	28
Total increase			163

Respectfully submitted,

WM. H. WAHL,

Chairman of Committee on Instruction.

PHILADELPHIA, January 1, 1903.

ANNUAL REPORT OF THE COMMITTEE ON PUBLICATIONS FOR 1902.

To the Members of the Institute:

Your Committee on Publications has nothing special to record respecting its operations during 1902, and wishes simply to reiterate the general statements contained in its report for the previous year.

THEODORE D. RAND,

Chairman.

PHILADELPHIA, January 14, 1903.

ANNUAL REPORT OF THE COMMITTEE ON ELECTION AND RESIGNATION OF MEMBERS FOR THE YEAR 1902.

To the President and Members of the Franklin Institute:

The Committee on Election and Resignation of Members, by direction of the Board, has revised the list of members, and eliminated therefrom the names of a large number of life members whose addresses have been for many years unknown, and who are believed to be deceased, though the Institute has not been authoritatively so advised. The membership at the close of 1902, after such revision and the usual deductions on account of death, resignation and non-payment of dues, is 1,771.

ALEX. KRUMBHAAR,

Chairman.

January 1, 1903.

ANNUAL REPORT OF THE COMMITTEE ON SECTIONAL ARRANGEMENTS FOR THE YEAR 1902.

To the Members of the Institute:

The Committee on Sectional Arrangements is pleased to transmit herewith the report of the operations of the six Sections of the Institute, giving details of the scientific and technical work accomplished by those bodies during the past year.

The Committee is much gratified to be able to report that the activity of the Sections continues unabated, and that both in the number of the communications contributed by them, and in character, the Section work is most creditably maintained.

JAMES CHRISTIE,
Chairman Com. on Sectional Arrangements.

January 1, 1903.

(Appendix embracing the operations of the Chemical Section, the Electrical Section, the Mining and Metallurgical Section, the Mechanical and Engineering Section, the Physical Section and the Section of Photography and Microscopy.)

To the Committee on Sectional Arrangements.

GENTLEMEN: During the past year a radical change was introduced in the manner of holding the meetings of the Sections. Instead of holding separate monthly meetings as heretofore, the Sections, on the recommendation of their respective Executive Committees, have been meeting in joint session on Thursday evening of each week.

The plan was promoted principally for the reason that the communications presented frequently interested the members of several Sections, and it was deemed expedient to give all the Section members the opportunity of attending these meetings.

The plan has worked well in practice, and has had the added advantage of considerably increasing the attendance, which has been much above the average attendance of previous years.

It has also been decided by separate action of the Sections to ask the Committee on Sectional Arrangements to name an Executive Committee for each Section to conduct its necessary business affairs, appoint officers, etc., thus simplifying their administration.

The general efficiency of the Sections has been maintained in a very satisfactory manner. The number of communications presented at the meetings has been large, and their character, as a rule, of a high order of excellence, and they have provided the Committee on Publications with an abundance of acceptable material for the *Journal*. . . .

WM. H. WAHL,
for the Secretaries.

ANNUAL REPORT OF THE LIBRARY COMMITTEE FOR 1902.

To the President and Members of the Franklin Institute.

GENTLEMEN: The Committee on the Library respectfully reports the following summary of the operations of the Library during the year 1902:

Bd. Vols.	Unbd. Vols.	Pphs.	Chts.	Phts.	Mss.	Clippings.
890	277	836	1	18	1	1

Total for the year 2,024

A decrease of 11 from 1901, and of 1,385 from 1900.

Total number of volumes, January 1, 1903 54,529

Total number of pamphlets, January 1, 1903 38,727

The Library also contains 2,456 maps and charts, 659 drawings and designs, 1,243 photographs, 192 newspaper clippings, 31 manuscripts.

Bound during the year 419

Exchanges.—There are now 523 societies and publications on the exchange list of the *Journal*—an increase of 11 over 1901.

The additions to the Library are again fewer than for any one of the last twenty years, owing mainly to the continued uncertainty of the income. The Moore Fund, ordinarily yielding about $750 yearly, the Lea Fund about $150 yearly, and the Memorial Library Fund about $50 yearly, have in the past year supplied but few books; but the James T. Morris Fund, about $100 a year, has begun to yield a number of volumes. The funds, however, have now begun again to produce their usual income.

The daily number of visitors to the Library has much diminished, in consequence of the Board of Managers' instructions to be strict about granting the privileges of the Library to those not entitled to them. The hope has been that thereby the usefulness of the Library may not be lessened, while the presence of idlers is discouraged, and others are led to appreciate more highly the privileges of membership. There is an increased number of evening visitors, under a recent re-arrangement of the hours, whereby the Library is open until ten o'clock on Tuesday and Thursday evenings, as well as the Wednesday evening of the monthly meetings of the Institute.

The binding is still deplorably backward and there is great need of binding at once about 500 volumes at an expense, now, of about $500. After that about $300 a year would cover the cost of binding the serial publications as fast as the volumes are completed, saving them from speedy ruin. There are also many volumes of not yet completed sets of periodicals that ought to be bound without further delay, if it were only possible to pay the expense, probably $100. The 372 volumes bound include a portion of the "periodicals of sets not yet completed," besides current periodicals.

The north room of the lower floor has been in satisfactory use the past year, and nearly all the shelves put in a year ago are already filled with Congressional Reports. The Board of Managers has now turned over the south room likewise to the Library, and it is used as a storage room for charts, duplicates and completed volumes of periodicals ready to go to the binder. It is highly desirable that the walls should be shelved during the coming year, for the space so given would be useful in many ways.

The large and exceedingly valuable collection of pamphlets has not yet found space on the shelves in these lower rooms, and still needs arranging and complete cataloging. The need of an additional assistant for this work is extremely pressing; and, as mentioned last year, the same assistant could give the much-needed closer attention to following up the collection of the numerous municipal and governmental serial publications of great engineering value, and countless useful trade catalogues.

The valuable collection of United States Geological Survey maps are still sorely in need of a suitable case of shallow drawers, where they would be conveniently accessible without injury from excessive handling. Estimates were obtained for such a case and it was found it would cost $125.

The crying needs of the Library, outside of the ordinary expense for the coming year, for binding, for completion of the fitting up of the northern room, shelving the walls of the southern new bookroom, an additional assistant, map case, and certain much-needed books beyond reach of the special funds, demand an appropriation of $2,475.

The members of the Library Committee still maintain untiring zeal in the interest of the Institute.

BENJAMIN SMITH LYMAN,
PHILADELPHIA, January 12, 1903. *Chairman Committee on Library.*

REPORT OF THE COMMITTEE ON MEETINGS FOR THE YEAR 1902.

To the President and Members of the Franklin Institute :

Your Committee on Meetings has provided for the ten monthly meetings prescribed as its duty, and believes that in general interest the meetings of the past year will compare favorably with those of former years. The best evidence of this fact is to be found in the figures of attendance, and in this respect the Committee is pleased to be able to report a notable increase.

WASHINGTON JONES,
January 1, 1903. *Chairman Committee on Meetings.*

ANNUAL REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS FOR THE YEAR 1902.

HALL OF THE FRANKLIN INSTITUTE.

To the President and Members of the Franklin Institute:

The following report of the Committee on Science and the Arts is respectfully submitted :

The number of cases pending on December 31, 1901, was		47	
The number of new cases proposed in 1902 by application was	31		
By reference from Institute	6		
By reference from Sections	1		
By vote of the Committee	24		
Total number of new cases in 1902		62	
Total number of cases before Committee in 1902			109
Number of cases acted upon	51		
{ of which there are pending, 7. withdrawn, 2.			
Finally determined		52	
Cases pending December 31, 1902		57	
			109

The fifty-two cases completed were determined as follows :

Award of Elliott Cresson Medal	2
Award of John Scott Premium and Medal	12
Award of Edward Longstreth Medal of Merit	8
Award of Certificate of Merit	4
Reports without award	5
Carried forward	31

Brought forward	31
Reports advisory	11
Cases withdrawn	2
Cases dismissed	8
Total	52

During the past year, the recommendation of the Committee that the By-laws of the Institute be amended so as to permit of the increase of the membership of the Committee from forty-five to sixty, was carried into effect. Sufficient time has not yet elapsed to permit all the advantages of this increase of working force to be fully realized, but these will, no doubt, be very apparent in the coming year.

The directions of the Institute for the issue of diplomas with the medals awarded by the Committee were also carried into effect, a very liberal arrangement with the American Bank Note Company and the Board of Directors of City Trusts having enabled the Committee to provide practically the entire cost of the engraving without calling on the Institute to furnish the funds for the purpose. The diplomas, which are most artistically designed and well executed are now ready for issue to the recipients of the medals; and they will doubtless add materially to the publicity of the Institute's awards and increase their usefulness.

From the preceding summary statement of the Committee's operations, it will appear that the amount of work accomplished during the past year slightly exceeded that of the year 1901. The number of cases submitted for investigation, however, considerably exceeded the number of the previous year, and the number of cases pending on the Committee's Record Book is also considerably greater. In fact, the Committee members, even with the enlarged numbers, have as many assignments for Committee duty at present as they can properly care for.

THOS. P. CONARD,
Chairman Committee on Science and the Arts.

PHILADELPHIA, January 1, 1903.

Committee on Science and the Arts.

(*Abstract of proceedings of the stated meeting held January 7, 1903.*)

MR. THOS. P. CONARD in the chair.

The following reports were adopted:

(No. 2222.) *Theory of Musical Harmony.*—Dr. Victor Goldschmidt, Heidelberg, Germany.

This report is reserved for publication in full. The Elliott Cresson Medal is awarded to applicant. [*Sub-Committee.*—Dr. Joseph W. Richards, Chairman; E. Goldschmidt, J. Fred. Wolle, C. C. Heyl, G. A. Hoadley.]

(No. 2229.) *Hydrocarbon Burner.*—C. Francis Jenkins, Washington, D. C.

(An advisory report.)

(No. 2248.) *Photo-polychrome Printing Process.*—Henri Bürger, Zürich, Switzerland. Reserved for publication in full. The award of the John Scott Premium and Medal is recommended to the inventor. [*Sub-Committee.*—Louis E. Levy, Chairman; Samuel Sartain, Max Rosenthal, W. N. Jennings].

(No. 2257.) *Blue-Printing.*—Pittsburgh Blue Print Co., Pittsburgh, Pa.

ABSTRACT.—The improvement embraces an apparatus devised by Samuel Brent Whinery, of Pittsburg, intended for the production of blue-prints, and is designed to facilitate the manipulation of cylindrical glass-printing frames in the process of photographic printing by electric light on paper or other flexible material sensitized for the purpose, through a flexible negative or positive, such as a drawing on transparent material or a photographic film stripped from its glass support.

The apparatus, in general terms, may be described as consisting of the above-named glass cylinder, made of two longitudinal halves, which is adapted to receive the transparency and sensitized paper on its entire surface, and an electric arc-lamp arranged to move up and down through the upright cylinder, and having its speed controlled by suitable mechanism.

The essential features of this apparatus, namely, the substitution of a cylinder of glass in place of the ordinary flat-printing frame, the application of an electric lamp moving through the axis of the cylinder, and the determination of the time of exposure by a measured movement of the source of light have long been in use, and are not claimed as new.

The novel features presented in the present arrangement are, first, a method of securing two flap covers tightly around the outside of the semi-cylinders over the transparency and paper by means of specially devised holders on one of the uprights of the frame, and of spring catches to fasten the free end of the flaps to the upright on the opposite side; second, a carbon holder for the electric lamp adapted to permit the lower carbon to be rotated on its axis for proper adjustment in relation to the upper one, and, third, an escapement mechanism for adjustively regulating the descent of the lamp in the cylinder, and correspondingly determining the deviations of the exposure. These devices are each covered by letters-patent numbered 699,355, 702,514 and 704,415, dated, respectively, May 6, June 17 and July 8, 1902.

In consideration of the improvements embodied in these devices the Certificate of Merit is awarded to the inventor. [*Sub-Committee.*—L. E. Levy, Chairman; Samuel P. Sadtler, Chas. E. Ronaldson, Martin I. Wilbert.]

(No. 2247.) *Dirt Eradicator for Trolley Lines.*—Henry C. Mayer, Blooming Grove, Pa. (An advisory report.)

First reading.

(No. 2230.) *Speed Controller.*—Consolidated Machine Specialty Company, Boston, Mass.

(No. 2249.) *Magnetic Clutch.*—Bion J. Arnold, Chicago, Ill.

(No. 2250.) *Multiple Unit System of Electric Traction.*—Frank J. Sprague, New York.

(No. 2267.) *Apparatus for Measuring and Recording the Variable Diameter of Tubes.*—L. Bancroft Mellor, Philadelphia.

(No. 2269.) *Horizontal Folding-Door.*—Wm. A. Cross, Chicago, Ill.

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JOURNAL

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CHEMICAL SECTION.

Stated Meeting, held Friday, January 2, 1903.

Stability Tests for Nitro-Cellulose and Nitro-Cellulose Powders.

BY ALBERT P. SY,
Ordnance Department, U.S.A.

Stability tests for explosives are little known outside of the manufacturers' and the Government laboratories. The object of this article is to present a review of the more important and most-used tests, especially those used at the Frankford Arsenal.

"Stability tests," sometimes also called "heat tests," are applied to explosives to determine their stability or keeping qualities. By the manufacturer these tests are also used during the process of manufacture to determine if the product has been sufficiently purified.

*The Abel Test.**—This is the oldest test for stability and one which is still used extensively, especially in England.

* *Transactions Royal Society*, 1866, 269.

In this test the explosive is heated to temperatures varying from 65·5° to 100° C., and the time noted which is required to produce a discoloration on a test-paper of potassium-iodide starch.

At this laboratory this test is conducted as follows:* 1·3 gram of the sample (air-dried) is placed in a test-tube 6 inches long by ½ inch wide. The test-tube is then closed by a cork carrying a glass rod, the latter having a hook of platinum wire fused in at the lower end. On this hook there is suspended a strip of the KI-starch test-paper moistened to one-half its length with a 50 per cent. glycerin solution. (*Fig. 1.* Test-tube shown one-half actual size.) The position of the test-paper in the test-tube is so adjusted that the line dividing the dry and wet portions of the paper is on a level with the lower edge of the film of moisture expelled from the explosive and deposited on the inside of the test-tube. The tube is immersed in a bath, the temperature of which is regulated to 65·5° C. (± 1°) for nitro-cellulose, and to 100° C. (± 1) for smokeless powders (nitro-cellulose powders). The arrangement of this bath is shown in *Fig 1.* Into an open water-bath there is placed a copper vessel containing water or glycerin, having a cover consisting of three perforated and parallel disks about 1 inch apart. The holes in the upper and middle disk are just large enough to admit the test-tubes, while those in the lower disk are smaller. This arrangement serves to hold the tubes all at the same level and in a vertical position, and is a decided improvement over the old form of apparatus usually shown in connection with this test.

When the bath has reached the required temperature the tubes with the sample are immersed and the test begins at this moment; it ends at the appearance of a brown line on the test-paper at the juncture of the dry and wet portions. For a good nitro-cellulose this discoloration must not take place in less than forty minutes (at 65·5° C.), and not less than ten minutes (at 100° C.) for a good nitro-cellulose powder. Powders containing nitroglycerin should

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* Standard Methods of Chemical Tests of Nitro-Cellulose, etc., prescribed by Ordnance Department, May 1, 1902.

FIG. 1.—Stability tests of nitro-cellulose and nitro-cellulose powders. Potassium iodide and starch test.

stand the test for twenty minutes at 65·5° C. This discoloration of the potassium-iodide starch paper is due to the action of free iodine on the starch, the iodine being liberated from the KI by impurities, or products of decomposition* volatilized from the sample.

This test as described, or with some slight modification, especially in the temperature employed, is more extensively used than any other. However, it is of most value to the manufacturer, since by careful application of the test he can determine whether nitro-cellulose or nitroglycerin is perfectly free from traces of acid. The test could be called a "purity test" more appropriately than a "stability test." When applied to finished products this test has many weak points which have been pointed out by other chemists and corroborated by results obtained in this laboratory after years of use.

(1) It shows in cases of decomposition during the test only the beginning and not the continuation of the decomposition.†

(2) Traces of unstable nitro-compounds would show a nitro-cellulose, or a powder in which they are found by this test to be bad; yet these traces of comparatively unstable compounds might not cause a decomposition of the explosive if kept under ordinary conditions. And, considering that there is no indication as to the effect of these traces of unstable compounds, this test does not indicate the keeping qualities of the explosive.

(3) In case of a nitro-cellulose powder, this test may be affected by traces of solvents left in the powder.

(4) The weakest point of this test lies in the fact that it can be masked by a number of substances which are sometimes added to the explosive for that purpose. Mercuric chloride, or mercury salts, are most frequently used for this purpose.‡

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* Principally nitrogen oxides and acids.

† Will: Mittheilungen a.d. Centralstelle f. wissenschaft. Untersuchungen.

‡ "The presence, in the sample, of mercuric chloride, or alkali, or any other substance which might in any way mask or interfere with the heat test, will be sufficient to cause its rejection." Stand. Meth. of Chem. Tests. Prescribed by Ord. Dpt. U. S. Army, p. 3.

According to Thomas,* $HgCl_2$ is reduced to Hg which unites with the oxides of nitrogen, preventing volatilization of the latter, and consequently retards the reaction on the test-paper. A test-paper which shows the reaction is readily bleached when exposed to vapors of mercury. Samples of nitro-cellulose have been received at this laboratory, which contained metallic mercury which had been added as such or had been reduced from a mercury salt.

Amines have been added to nitro-cellulose and powders in order to mask or lengthen the stability test.† Amines react with nitrous fumes as follows:

$$R . NH_2 + HONO = R (OH) + N_2 + H_2O.$$

Small quantities of alkalies or carbonates are sometimes added to neutralize remaining traces of nitrating acids, and also to combine with nitrous fumes resulting from decomposition.‡

Other substances used to mask the stability test are § acetic ether, acetone, oils, vaseline, aniline.

(5) Variations in length of stability indicated by this test may be caused by variations in the condition of the sample to be tested; the size of the grains or pieces, whether cut or rasped: || whether freshly prepared for the test, or exposed to the air for varying lengths of time, which would allow the escape of volatile substances which might indicate a bad stability if not allowed to escape. Moisture-content of sample affects stability time.

(6) Difference in test-papers gives results which vary

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* *Zeit. f. Ang. Ch.*, 1898, 1027.

† *Zeit. Ang. Ch.*, 1899, 705.

‡ The value of the presence of alkalies or carbonates in nitro-cellulose to increase stability by neutralizing acids is a disputed point. Guttmann (*Zeit. Ang. Ch.*, 1897, 233) discourages this practice, contending that the real decomposition of a nitro-cellulose soon develops more than enough acid to be neutralized by the small amount of added alkali. Under some conditions, alkalies decompose or saponify nitro-compounds.

§ *Zeit. Ang. Ch.*, 1897, 233.

|| *Zeit Ang. Ch.*, 1897, 265. Guttmann found that it required eight and one-half minutes to heat ground cordite from 12° to 69½° C.

greatly and are in no way comparative.* The age of the test-paper also affects its sensitiveness.†

(7) The personal equation of the operator enters as a factor in causing variations. It is no easy matter to decide just when there is "the first appearance of the brown line" on the test-paper, or just when the line is of the same intensity as a standard.

From what has been said, it must be apparent that this test, the potassium-iodide starch test, has too many weak points to make it a reliable one for determining the stability of nitro-cellulose or powders. The test is made on all nitro-cellulose and powders received at this laboratory, the same operator making all the tests under as nearly uniform conditions as possible. However, no explosive is condemned on the results of this test alone.

THE GUTTMANN TEST.‡

This is the Abel test modified by substituting a test-paper of diphenylamin for the potassium-iodide starch paper. Guttman claims for it the following advantages over the Abel test:

(1) Not as sensitive.

(2) Test-paper more easily prepared.

(3) Masking substances do not interfere as much.

He had reviewed the literature and tried nearly all the reagents which had been used for detecting nitrous acid for the last forty years, and finally selected diphenylamin as the one which is best adapted for his modification of the Abel test.

The apparatus used is the same as given in the books for the Abel test. Temperature 70° C. instead of 65·5° C.

The test-papers are made by moistening the upper half of a strip of clean filter paper with the following solution:

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* The test-papers used by the Ordnance Department U. S. A. are made in quantity by Eimer & Amend, New York, according to specifications, thereby insuring greater uniformity than if made at different laboratories in small quantities. Manufacturers who have contracts with the Ordnance Department are supplied with these papers.

† *Journ. Soc. Ch. Ind.*, 1901, 8.

‡ *Zeit. Ang. Ch.*, 1897, 233. *Journ. Soc. Ch. Ind.*, 1897, 283.

Diphenylamin	0·1 gram.
Sulfuric acid	10 c.c.
Water	42 c.c.
Pure glycerin	50 c.c.

This solution must be kept in the dark.

The effect of nitrous fumes on this test-paper is to turn it from colorless to a greenish yellow, after which a blue color should follow in a few seconds.

Thomas says* the diphenylamin-test is unsatisfactory. It may be masked by adding diphenylamin to the sample under examination, in which case the paper will turn yellow, but not blue. Guttmann himself admits that the blue color sometimes fails to appear; in such case he repeats the test. He also says † that the test is vitiated by moisture in the sample, causing a dilution of the reagent on the test-paper. Thomas' claim that diphenylamin test-paper gives no sharp reaction (*i. e.*, a decided blue color in a short time after the greenish yellow) is corroborated by other chemists.

The Guttmann test was tried at this laboratory but gave unfatisfactory results. Thomas, Aspinwall,‡ Spica,§ find sufficient objections, after trial, to discard it. Major Nathan says || that the Guttmann test fails when testing volatile explosives such as nitroglycerin. Nitroglycerin is decomposed by the sulfuric acid on the test-paper.

The Zinc-iodide Starch Test is a modification of the Abel test, using zinc-iodide instead of potassium-iodide and a temperature of 80°. The reasons for using zinc-iodide seem to be its greater sensitiveness ¶ and its action as a preservative of the test-paper. The increase in sensitiveness is in no way an improvement of the Abel test, and results obtained at this laboratory show that the modification is not more

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* *Zeit. Ang. Ch.*, 1898, 1027.

† *Zeit. Ang. Ch.*, 1898, 1103.

‡ *Journ. Soc. Ch. Ind.*, May 31, 1902.

§ Spica: Rivista, Ang., 1899.

|| *Journ. Soc. Ch. Ind.*, 1901, 10.

¶ Guttmann, in Lunge: "*Ch. Tech. Untersuchungsmeth.*," II, p. 492, says: Zinc-iodine test-paper is about one-third more sensitive than potassium-iodide paper.

reliable than the original. The requirements for stability by this test vary greatly. Using 80° C.:

Prussia (official test) requires for nitro-cellulose		25	min.
Holland " " " " "		20	"
" " " " "	N. C. powder	10	"
" " " " "	nitroglyc. powder	10	"
Denmark " " " "	nitro-cellulose, before addition of $HgCl_2$	10	"
" " " "	after addition of $HgCl_2$	60	"
Troisdorff test requires for N. C. powder		80	"

This test has all the weak points mentioned under the Abel test.

THE HESS TEST.

As early as 1879 Hess realized that in testing explosives for stability it is not sufficient to know when decomposition begins, as indicated by the Abel test and its modifications, but it is also necessary to know how decomposition proceeds. One of the first attempts to follow for some time the decomposition of an explosive is described by Hess.* He heated nitro-cellulose to 70° C. in a tube and, by means of a current of air, carried the volatile products of decomposition into a dilute potassium-iodide starch solution. He made five observations or readings—four colorimetric readings of the potassium-iodide starch solution, and the time required for exploding the substance.

The weak points of this test are that, like the Abel test, it is far too sensitive and may show decompositions which in reality do not indicate instability of the powder. The test is also subject to interference by masking substances as described under the Able test.

THE HOITSEMA TEST.†

Another test, in which an attempt is made to show the progress as well as the beginning of decomposition, is described by Hoitsema. He heated nitro-cellulose for fifteen minutes at a constant temperature, and then, by

* "Mitth. ü. Gegenstände d. Artill. u. Geniewesens," 1879, 345. *Dingler Polytech. Journ.*, 234, 43.

† *Zeit. Ang. Ch.*, 1899, 705.

means of a current of carbon dioxide, passed the products of decomposition through glass-wool moistened with Guttmann's diphenylamin solution (mentioned under Guttmann's Test). This operation was repeated, lowering the temperature 10° each time, until a temperature was found at which no decomposition took place, *i. e.*, at which no products of decomposition were formed which gave a color-reaction with the diphenylamin.

Here, as in the Hess Test, the test is too sensitive, and may be masked as mentioned under the Guttmann Test.

THE EXPLOSION TEST.

This belongs to a number of tests where the temperatures employed are higher, the decomposition greater, and the observations of the decomposition are made on less sensitive indicators than in the tests so far described. For the explosion test, a small sample (usually 0·1 gram) of the explosive is placed in a strong test-tube, which is then corked and placed into an oil bath which is heated gradually until the sample explodes. The temperature, below which nitro-cellulose and powders must not explode in order to be considered stable, varies in different places.

	Degrees C.
Denmark (official) nitro-cellulose	180
Holland (official) nitro cellulose powder	170
Troisdorff laboratory, small-arms powder	178
" " cannon powder	173
Westpf. Anhalt., Spreng. Act. Gesell. N. C. powder	178
" " " " " N. Glyc. powder	170

The explosion test is made at this laboratory on all nitro-celluloses and powders. The apparatus used (*Fig. 2*) consists of a paraffine bath provided with a thermometer, and a stirring apparatus operated by a small water motor. The bath has a cover with six holes for the explosion tubes (*Fig. 2*, tube shown one-half actual size). Into these tubes there is placed 0·1 gram of the sample, then lightly corked and put into the bath at 100° C. The bath is now stirred and heated at such a rate that the temperature rises 5° per minute. The temperature is noted when the sample explodes.

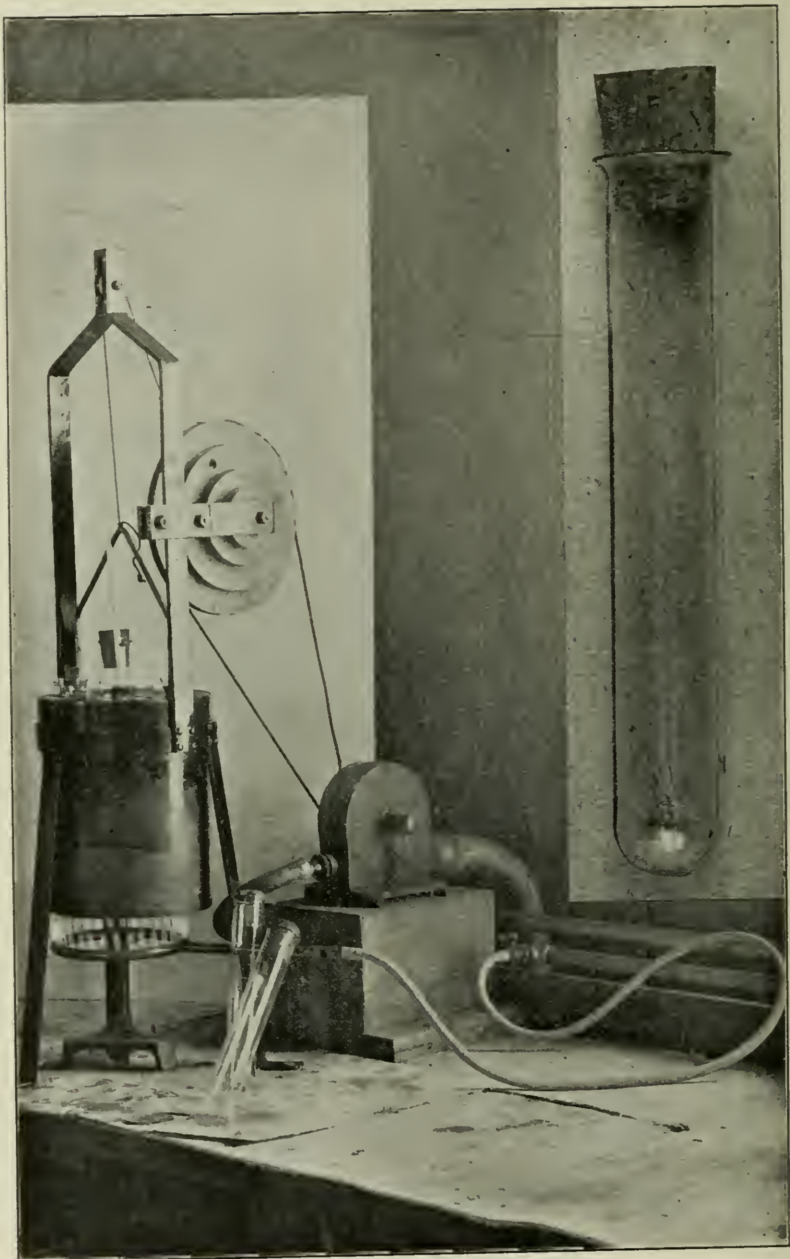

FIG. 2.—Stability tests of nitro-cellulose and nitro-cellulose powders. Explosion-test apparatus.

	Degrees C.
A nitro-cellulose must not explode under	186
" " " powder must not explode under	177
" nitro-glycerin " " " " "	170

Judging from a great number of explosion tests made on nitro-celluloses and on nitro-cellulose powders, it seems that this test is fairly reliable when the explosive is either very good or very bad. Uusually, a good nitro-cellulose will not explode below 186° C., and a good nitro-cellulose powder not below 177° C.; however, there may be variations of + or — 4° from these figures. For example:

Four apparently equally good powders—

	Degrees C.
Nitro-cellulose powder No. 396 exploded at	173
" " " " 797 " "	175
" " " " 799 " "	177
" " " " 800 " "	181

Three other nitro-cellulose powders, showing a very poor stability by all other tests,

	Degrees C.
No. 326 exploded at	161
" 391 " "	168
" 546 F. A. exploded at	170

Variation may be caused by different manipulation of the test, and by the physical condition of the sample. Duplicate samples sometimes vary 3°. On account of the volatility of nitroglycerin, the test is of little value in testing nitroglycerin powders.

The explosion test, therefore, is only a rough guide as to the stability of an explosive, but is of some value when made in conjunction with other tests.

THE THOMAS TEST.

This test* consists in heating the sample in a glass-stoppered tube, in an oil bath, for eight hours daily. A good nitroglycerin powder should stand four days' heating at 94°–96° C. without developing brown fumes (N_2O_4). A good nitro-cellulose and nitro cellulose powder should not show fumes before three days, using a temperature of 99°–101° C.

* *Zeit. Ang. Ch.*, 1898, 1027.

These temperatures are too low to produce a decisive decomposition, which may be observed by the appearance of brown fumes. At 100° C, or below, the decomposition of nitro-cellulose, or nitro-cellulose powder, is often so slow and gradual that it is difficult to say just when brown fumes appear. Captain Aspinwall† cites cases where nitro-cellulose required twenty-one days' heating to show brown fumes and says that the objection to this test is the length of time required to obtain definite results.

THE 135° TEST.

This test, which is also known as "the German test," is made on all nitro-celluloses and powders at this laboratory. It is a combination of several tests used in Germany and Switzerland.

Two and five-tenths grams of the sample to be tested are placed into a strong glass test-tube 320 millimeters long, and 15 millimeters internal and 18 millimeters external diameter; a piece of blue litmus paper is put into the tube about ½ inch above the explosive. The tube (*Fig. 3*, tube shown one-half actual size) is now lightly corked and placed into a bath at 135° C. This bath (*Fig. 3*) is made of heavy sheet-copper and closed at the top, into which are sunk twenty copper tubes closed at the lower end. The bath is about two-thirds full of commercial xylol, having a boiling point of 135° C.; a reflux condenser prevents the volatilization of the xylol. Into the copper tubes, which are surrounded by boiling xylol, are placed the glass tubes containing the explosive to be tested, in duplicate.

Three observations are made: (1) the reddening of the litmus paper; (2) the appearance of brown (N_2O_4) fumes, and (3) the explosion of the sample. The minimum time, as required by government specifications, is as follows:

	Litmus red.	Brown fumes.	Explosion.
Nitro-cellulose	:30	:45	5:00
Nitro-cellulose powder	1:15	2:00	5:00
Nitroglycerin powder	:30	:45	5:00

† *Jour. Soc. Ch. Ind.*, 1902, May 31.

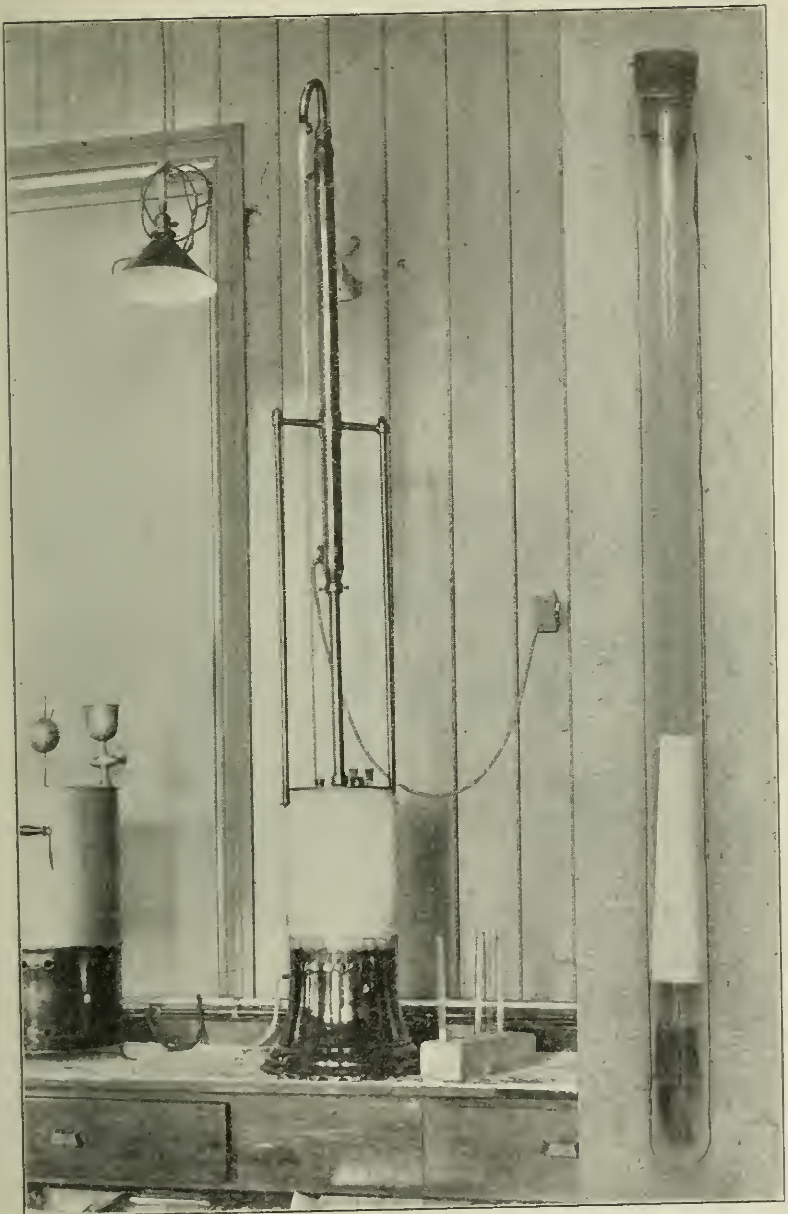

FIG. 3.—Stability tests of nitro-cellulose and nitro-cellulose powders. 135° C. test.

To make the results of this test as valuable as possible all three observations must be carefully studied and compared with those obtained from standard or good products.

FIG. 4.—Stability tests of ni.ro-cellulose and nitro-cellulose powders. Vieille's test.

The temperature 135° C. is usually considered too high for stability testing, as it may cause decomposition not always dependent upon the stability of the explosive.

Again, very often it is impossible to say just when the litmus paper is red, and two operators have been known to vary thirty minutes in this observation. The same is true of the "brown fumes" observation, the readings varying from traces to dark fumes. There is never any doubt as to the third observation—the explosion.

Different makes of litmus papers give results for "litmus red" varying considerably. To avoid errors on this account, the litmus papers used by the Ordnance Department are all made, according to specifications, by Eimer & Amend, N. Y., of as nearly uniform quality and sensitiveness as possible.

By keeping all conditions as nearly uniform as possible, and by observing all precautions mentioned, the "135° test" is one of the best of this class.

THE VIEILLE TEST.

Vieille heats the explosive in a closed glass tube until blue litmus paper is turned red. The temperature used is 110° C., which, after having made a great number of experiments, Vieille decided upon as being most suitable for this test. The Vieille test is used by the Ordnance Department on all nitro-celluloses and nitro cellulose powders.

The apparatus used (*Figs. 4* and *5*) consists of a circular double-walled air-bath filled with glycerin between the walls. Near the top and on the outside of the bath there is a gas regulator (*Fig. 5*); its action depends upon the pressure produced by the expansion of the glycerin as it becomes heated and rises in a glass tube in the top of the bath. On the inside of the bath there is a revolving horizontal tray for carrying the bottles which contain the explosive. A port-hole through the walls of the bath, and a reflector for throwing light into the bath, serve for observation of the explosive without opening the top of the bath or taking out the tray. The bottles are 27 by 85 millimeters and are closed air-tight by a metal cover and clamp and a rubber washer. A short thermometer, having a range of 10° (105° to 115° C.) is placed in one of the bottles and the latter closed in the same way as those containing the samples. A second thermometer extends through the cover of the bath into the

interior and serves as a guide to the operator; the temperature which it registers when the bottle-thermometer registers 110° C. is chalked on the bath.

For the test, 10 grams of the sample are taken in normal condition, and in one piece when possible, and placed in a Vieille bottle. A piece of blue litmus paper is inserted half-way between the top of the sample and the cover of the bottle in a scroll or "S" form, so as to allow free access of the fumes to both sides of the paper. The bottle (*Fig. 4*,

Gas regulator.

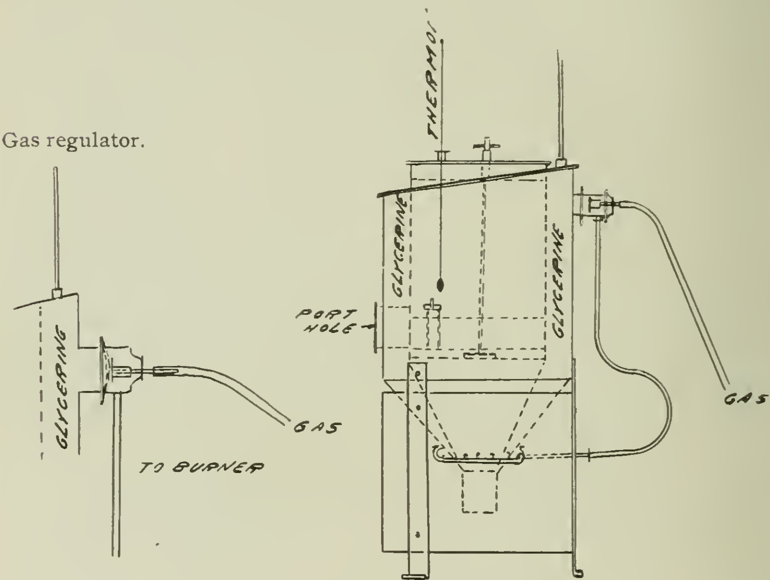

Fig. 5.—Vieille's apparatus.

bottle shown one-half actual size) is then closed and placed in the tray, and the latter put into the bath at 110° C. Triplicates are taken. The bottle is kept in the bath until the paper is thoroughly reddened, the time required is noted, the bottle removed and opened. This operation is repeated daily, using a clean bottle and fresh litmus paper, until the time required to redden the paper in one hour or less. These daily times are added and the total (accumulated time) should not be less than

Thirty hours for large powders,
Twenty hours for small powders,
Ten hours for nitro-cellulose.

Experience at this laboratory proves that this test is not applicable to nitroglycerin powders since they are liable to explode. A temperature of 110° C. is too high to heat confined nitroglycerin powders, since volatilization of nitroglycerin is too great at this temperature.

At first the Vieille test promised good results, but after applying it to nearly 1,000 samples it is found difficult to obtain reliable results. The shortcomings of the test are:

(1) In common with all other heat tests when blue litmus is used, it shows only acid products of decomposition.

(2) It is practically impossible to get all the Vieille bottles equally tightly closed. Experiment has shown that pressure is an important factor in the decomposition of nitro-cellulose products; the greater the pressure the less the stability time.

(3) The personal equation of the observer in reading the reddening of the litmus paper.

(4) Varying results are obtained unless the litmus papers be uniform.*

To show how (2) and (3) may affect the test, the following example is given. Powder used, No. 374; three bottles, prepared as nearly alike as possible; readings taken by operator who usually makes this test:

	1st day.	2d day.	3d day.	4th day.	5th day.	6th day.	Total.
1	5.15	3.20	3.00	2.40	2.05	1.35	17.55
2	5.15	4.00	3.00	2.10	1.10	1.30	17.05
3	5.15	3.20	3.00	2.40	3.00	2.20	19.35

THE WILL TEST.

Of the tests so far described, some show only the beginning of decomposition, while others show the beginning and

* The litmus papers used at this laboratory are the same as described under the "135° C. Test."

roughly also the progress of decomposition. None can properly be called a quantitative test.

No better reasons for the need of an entirely new test, and one that is quantitative, could be given than those of Professor Will in his report of December, 1900, in "Mittheilungen a. d. Centralstelle f. Wissenschaft. Untersuchungen," Neu Babelsberg, near Berlin (abstract in *Journ. Soc. Ch. Ind.*, June 30, 1900). He enumerates the deficiencies of the tests now in general use, and our own experiences, as mentioned under the above-described tests, fully agree with what Professor Will says.

Will's test consists in decomposing nitro-cellulose at 135° C. in a stream of carbon dioxide, reducing and absorbing all products of decomposition so as to leave only nitrogen gas, which is measured at regular intervals in a burette, and the rate of evolution of nitrogen is taken as an index of the decomposition. The use of such a high temperature as 135° C. necessitated an investigation to determine whether a definite relation exists between different temperatures and rates of decomposition; *i. e.*, whether the stability or decomposition of a nitro-cellulose varies regularly with the temperature. It could be safely assumed that the stability of a nitro-cellulose decreases and decomposition increases as the temperature to which it is subjected increases. Will's exhaustive experiments prove that such parallelism exists. Vieille's experiments, cited by Captain Aspinwall (*Journ. Soc. Ch. Ind.*, May 31, 1902), show that a distinct relation exists between time and temperature to which a nitro-cellulose, or powder, may be exposed before breaking down.

Will's apparatus is shown and described in his second report, January, 1902. It consists of (1) a Kipp generator for making carbon dioxide; (2) decomposition tube, for heating and decomposing the sample; (3) reduction tube, for reducing nitrogenous products of decomposition to nitrogen; this tube contains spirals of copper-wire gauze; (4) gas burette, for collecting and measuring the nitrogen; (5) metal shield for protecting operator in case of explosions. After placing the sample in (2), the whole apparatus is connected air-tight, and a slow stream of carbon dioxide is

passed through until all air is driven out. By means of an oil-bath the tube containing the sample is heated to and kept at 135° C.; a slow, uniform current of carbon dioxide carries the products of decomposition into the reduction tube, and from there into the burette, which is filled with a strong solution of sodium hydrate; the volume of the nitrogen gas is read every fifteen minutes.

A nitro-cellulose, which by this test gives equal quantities of nitrogen in equal intervals of time, Will considers as being stable, or in "the limit state" of purification.

Considering the main principle of this test, and in theory, it should give better results than those obtainable by any other test so far described. Will's test was thoroughly tried by Mr. C. P. Beistle, of this laboratory, no expense nor time being spared in setting up the rather elaborate apparatus required and in conducting the test. A number of tests were made, but the results obtained were unsatisfactory and the test was discontinued. Briefly, the following reasons are given as the cause of unsatisfactory results:

(1) The temperature of 135° C. is too high for stability-testing purposes.

(2) The decomposition is measured only by the nitrogen evolved.

(3) From Professor Will's experiments and diagrams it is not at all clear where to draw the line (except very roughly and in a most general way) between a stable and an unstable product.

(4) The statement is made that for a certain nitro-cellulose, heated for thirty hours and losing one-fourth its original nitrogen, the evolution of nitrogen in equal intervals of time was identical; while in another place it is stated that 10 grams of nitro-cellulose gave 4 times the quantity of nitrogen that were given off by 2·5 grams. It is not easy to understand how it is possible, even in a perfect product, to get equal quantities of nitrogen in equal intervals of time, since the amount of unchanged material is constantly decreasing. The two statements therefore seem contradictory.

(5) It is practically impossible to get a carbon dioxide which is free from air; and as it is exceedingly difficult to

pass the carbon dioxide through the apparatus at a uniform rate, the air-content of the gas gives rise to serious errors. Further, if the carbon dioxide is conducted too fast it cannot be sufficiently heated in the pre-heating coil before it comes in contact with the sample, and may not be completely absorbed by the soda solution. If the current be too slow, the gases of decomposition are not carried away fast enough, and this may affect the course of the decomposition.

(6) If the reduction tube and copper spirals are not heated sufficiently high, or the current of carbon dioxide passed too fast, some of the products of decomposition may escape reduction and will not be absorbed by the soda solution.

(7) Quite unstable products are liable to explode, which might cause considerable annoyance, both to the operator and the apparatus.

From what has been said about these methods of testing, it is obvious that the stability of an explosive cannot be determined from any one method alone. At this laboratory, the Abel or potassium-iodide starch test, the explosion test, the 135° C. test and the Vieille test are made on all nitrocelluloses and nitro-cellulose powders. A careful application of these four tests will detect an unstable product.

CHEMICAL LABORATORY, FRANKFORD ARSENAL.
PHILADELPHIA, January 2, 1903.

CEMENT FOR MARBLE.

The *Bandische Landes Zeitung* says that an excellent cement for broken marble consists of 4 parts of gypsum and 1 part of finely powdered gum arabic. Mix intimately, then with a cold solution of borax make into a mortar-like mass. Smear on each face of the parts to be joined, and fasten the bits of marble together. In the course of a few days the cement becomes very hard and holds very tightly. To get the best results the object mended with the cement should be left absolutely quiet for several days, not touching or moving it. In mending colored marbles the cement may be given the hue of the marble by adding the color to the borax solution.

CHEMICAL SECTION.

Stated Meeting, held Thursday, January 23, 1902.

Modern Methods of Rock and Mineral Analysis.

By Dr. W. F. Hillebrand,
U. S. Geological Survey, Washington, D. C.

(*Concluded from p. :26.*)

This ready oxidizability of titanium offers an easy means of separating zirconium from it quantitatively. It is only necessary after peroxidizing in not too strong sulphuric solution to add a soluble orthophosphate, whereby zirconium is quantitatively precipitated at once, if even only a few milligrams are present, more slowly if in smaller quantity.

This method, which seems to be good, doubtless admits of a separation of large amounts of zirconium from titanium; though if it were easy to obtain and always have on hand a strong and pure hydrogen peroxide it might be very advantageously employed alone without a phosphate, both as oxidizer for titanium and precipitant for zirconium in the state of superoxide, as first employed by G. H. Bailey. Either, however, necessitates resolution and reprecipitation, the final absence of the titanium peroxide coloration being a sure sign of complete removal of that element. Prior to the publication of Bailey's work there was no means of separating with any certainty the zirconium in rocks, hence the frequent failure to recognize it as a rock constituent.

Another method, similar in principle to the old titanium method, has been applied by Baskerville to separation of both titanium and zirconium from aluminum and iron, and with very considerable success. It consists in boiling, for only a few minutes, the chloride instead of sulphate solution, previously nearly neutralized with ammonia, in presence of sulphur dioxide. While it promises well, its general applicability has not yet been tested, but it is certainly vastly preferable to its prototype.

Directly connected with the presence of titanium in rocks, clays and many ores is a modern modification in the volumetric method of total iron estimation. Reduction by nascent hydrogen prior to titration involves an error when titanium is present, by its partial reduction to a lower oxide, hence the necessity for a method of reduction which should eliminate this error. It was found in the substitution of hydrogen sulphide for hydrogen, followed by boiling out the excess of reducing agent and cooling in a carbon-dioxide atmosphere. This elegant method, too little employed as yet, affords irreproachable results, and it is not even necessary to remove by filtration the sulphur which separates as a result of oxidation of the hydrogen sulphide, unless metallic sulphides are mingled with it, for on pure sulphur in the cold permanganate is without action.

Since vanadium is, like titanium, an extremely common constituent of nearly all rocks, and hence of soils and clays, and if present is one of the components of the familiar mixture we are still discussing, its influence on the estimation of total iron must be considered in all very refined work. This, of course, can only be done when the percentage of vanadium is known, in which case it is only necessary to allow for its oxidation from V_2O_4 to V_2O_5 (after reduction by hydrogen sulphide, but not by hydrogen) in order to obtain the correction for total iron.

Since vanadium occurs in soils and rocks apparently in the trivalent state, replacing aluminum or ferric iron in certain silicates, it must necessarily be allowed for in determining the ferrous iron that may exist in a rock or mineral. Here, of course, it consumes twice as much oxygen in being converted to V_2O_5 as was the case in estimating total iron, where it had only to be oxidized from V_2O_4 to V_2O_5. This correction is readily applicable by either of the two methods in vogue for determining ferrous iron, provided there are absolutely no traces of sulphides present.

With regard to the old Mitscherlich method for determining ferrous iron, by heating in a sealed tube with sulphuric acid, it has been shown that unless the tube is filled with carbon dioxide gas passing in a current up to the very

instant of sealing the tube, instead of by the very unreliable one of introducing sodium carbonate crystals or solution, the results will inevitably be low, for only in the former way can complete exclusion of air and consequent success be secured.

I said just now that only in absence of sulphides could the proper correction for V_2O_5, if present, be applied when using the Mitscherlich or sealed-tube method, and this for the same reason that makes the presence of these sulphides fatal to the ferrous-iron estimation itself. It was only when the almost never-failing presence of sulphides in all sorts of rocks became impressed upon me, by persistent testing for sulphur in them, that their influence in explaining certain marked discrepancies between results by the Mitscherlich and the hydrofluoric-acid methods of ferrous-iron estimation became apparent. It would perhaps not then have impressed itself but for the rediscovery by Stokes of the powerful reducing action of metallic sulphides on ferric salts, first announced by L. L. de Koninck. This action fully suffices to account for the excess of ferrous oxide (running all the way from nothing up to 2 or more per cent.) by the Mitscherlich method as against that by hydrofluoric acid, an excess which I recognized fifteen years ago, but had hitherto been unable to account for. Thus we are enabled to see that all, or nearly all, the early analyses of rocks, in so far as they contained sulphides, or carbonaceous matter, are affected by an indeterminable error. And since to the petrographer the exact determination of the two oxides of iron in a rock is of great importance for the calculation of the mineral constituents, it is clear that not much can be done with most of the analyses made before the introduction of the Cooke or hydrofluoric method about 1867. Fortunately, at the temperature of boiling water, the action on ferric salts of the relatively small amounts of pyrite found in rocks is insufficient to produce a serious error in the ferrous-oxide determination. Nevertheless, since other sulphides, which are readily soluble in hydrofluoric and sulphuric acids, as pyrrhotite, frequently do occur, it is manifest that an error is introduced of another kind which it is

next to impossible to allow for with any degree of certainty. Hence, although we have seen our way to overcome certain difficulties in its determination, we are still in want of a method which shall at all times give the true value for ferrous oxide, and consequently for ferric oxide, for an error in one is accompanied by its twin of opposite sign in the other.

Chromium, which may likewise form a part of our mixture, is readily determinable, and with great exactness, by a recent colorimetric method when it occurs in small amount, as is always the case in rocks and iron ores. This method consists in obtaining the chromium as chromate in alkaline solution of known volume and comparing its color with that of a standard monochromate solution. For large amounts I know of no special improvements in the older methods, but may say that the separation from alumina by hydrogen dioxide, announced a few years ago, is, like so many similar methods, not reliable.

I shall say little with regard to phosphorus, except that the causes for many discordant statements have been shown to lie in the varying composition of the ammonio-magnesian precipitate. Unless this is caused to form under certain conditions not always attainable, it will not on ignition have the normal pyrophosphate composition. Therefore, if the precipitate is at all large it is recommended by Gooch and Austin to decant, to redissolve the precipitate in as little hydrochloric acid as possible, to reprecipitate by dilute ammonia without further addition of magnesia mixture, and to wash finally with weakly ammoniacal water. Excess of ammonia, of ammonium salts and of precipitant are all objectionable. By decantation, without washing, enough of the precipitant is supposed to be retained to render further addition needless.

Rare earths may at times help to compose our now familiar mixture, but in such small traces as a rule, and so seldom looked for, that I will not take up your time by further allusion to them, except to say that as a group they can be separated and recognized without excessive trouble even when present in but a fraction of a milligram. The

ways of separating the members of this group are mostly based on long-known reactions, of which perhaps only one comparatively recent application in either qualitative or quantitative analysis deserves a word of comment. This depends on the insolubility of the fluorides of all the rare earth metals, without exception, in weak hydrofluoric acid. By the aid of it we are enabled to separate the entire group from all elements whose fluorides are soluble, provided there are no combinations present which will furnish insoluble double fluorides. Hereby, the analysis of such minerals as tantalite, columbite and samarskite is materially simplified and the detection of zirconium in presence of the earths is rendered easy. Moreover, the insolubility of its fluoride is a characteristic of uranium in the tetravalent state, but not in the hexavalent, so that we are hereby furnished with a means not only of separating these two uranium kations from one another, but also of ascertaining with ease the condition of uranium in a mineral by its appearance in the filtrate in one case or precipitate in the other when a mineral containing it is decomposed by hydrofluoric acid.

Now, as to that component, finally, of our mixture which, as I have already intimated, is so difficult of direct estimation when mingled with numerous other bodies, especially if phosphorus is one of these. To take up the reasons for this difficulty in detail would lead too far. Suffice it to point out wherein we have improved or learned to reject older methods of separation, then to mention one or two newer ones

Of the two old standby methods for separating aluminum from iron, by a fixed caustic alkali and by ammonium sulphide in tartrate solution, the former has been improved by fusing the solid mixture in a silver crucible instead of boiling its solution with the alkali. Hereby the separation is said to be rendered perfect, but both modifications labor under the disadvantage that if titanium is present—and in a rock analysis it always is—this goes to a small extent into solution with the aluminum, unless iron is simultaneously present in large excess. Many old analyses are therefore

affected by a slight error on this account, and even some foreign ones of to-day, for the method is still more or less in vogue abroad.

Of late years the search for organic precipitants of certain metals has been rather active, especially for those metals for whose separation good inorganic reagents are lacking. A number of such have been proposed, and among them phenylhydrazine as a precipitant for aluminum in presence of iron after reduction of the latter by a sulphite. Hess and Campbell, the discoverers, claim complete insolubility of the aluminum hydroxide in this reagent. Experiments made by Dr. E. T. Allen in our laboratory as to the availability of this method in presence of the usual rock constituents indicate that it is not available in presence of titanium and zirconium, for the reason that they are also thrown down. Since aluminum phosphate is likewise precipitated by phenylhydrazine, this reagent for ordinary rock analysis probably offers no anvantages over those commonly used. Moreover, it oxidizes rapidly, forming a brown scum, which is strongly adherent to the vessel and resembles ferric hydroxide so much as to greatly confuse the operator. Still, since the colorimetric as well as the gravimetric method for estimating titanium requires preliminary removal of iron when this is present in large quantity, the phenylhydrazine method may prove to be advantageous, since by it the aluminum, titanium and zirconium are obtained at once as a precipitate, and do not have to be recovered by a somewhat tedious operation from the tartrate filtrate from the iron sulphide.

With reference to manganese, the reasons why the results of precipitation as ammonio-manganous phosphate have not always been satisfactory have been worked out by Gooch and Austin. They have shown the cause to lie in the incomplete conversion of the first precipitated tri-manganous phosphate to the double salt, and claimed that to the attainment of satisfactory results the solution should contain not less than 10 per cent. of ammonium chloride. Very soon after this Dakin published a paper in which he showed that by precipitating with diammonium hydrogen

phosphate under very easily regulated conditions and in absence of any unusual amount of ammonium chloride a salt of normal condition was obtained, and that the final results were equally good, whether this was weighed as an ammonium salt by drying at 100°–105°, or as pyrophosphate.

He had already employed the same process with zinc, and extended it also to cobalt, with most excellent results in both cases.*

Because of the inconstancy in composition of mangano-manganic oxide, obtained by ignition of precipitated carbonate or peroxide, that mode of determining manganese has fallen somewhat into disfavor, and as a substitute the old method of converting to sulphate has again been brought into favor by Gooch and Austin, who show that it is expeditious and accurate when properly performed. In general it may be said that the principle of weighing as sulphate with accuracy has been extended to other metals with success as zinc, nickel, cobalt.

A further and convenient method for bringing magnesium, zinc, cadmium, manganese and nickel into the convenient forms of oxides is that first employed by Berzelius and extended by Volhard, Zimmermann, and Smith and Heyl. It consists in the evaporation and ignition of the chloride with an emulsion of pure mercuric oxide in excess. This principle is also sometimes applied to the removal of small amounts of magnesium in alkali determinations.

As with manganese the conditions favoring the precipitation of ammonio-magnesian phosphate of normal composition have been studied by Neubauer and also by Gooch and Austin, with the result that we now know that excess of precipitant, of ammonium salts, and of ammonia are all prejudicial to the formation of a precipitate which on ignition shall give only pyrophosphate. Usually the precipitate contains an admixture of a more highly ammoniacal phos-

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*Austin (*Am. Jour. Sci.*, August, 1902), has since taken exception to the conclusions of Dakin, and shown the probable existence of errors in the methods of analysis on which those conclusions were based.—W. F. H.

phate giving metaphosphate on ignition. Gooch, in particular, has tried to secure conditions of precipitation leading to the formation of normal ammonio-magnesian phosphate, while Neubauer seeks to obtain the pyrophosphate rather by long and strong blasting of the precipitate, whereby the excess of P_2O_5 is volatilized.

No one in careful work nowadays contents himself with a single precipitation of calcium as oxalate in presence of magnesium and alkalies, because of the well-understood contamination by these others. Only recently has T. W. Richards, in conjunction with some of his students, studied fully the subject of occlusion of magnesium oxalate by calcium oxalate and shown how by the observation of certain conditions results which are satisfactory by a compensation of slight errors are attainable by a single precipitation. Because of the lengthy personal attention of the operator it is possible that this simplification will not commend itself to general use, especially where much work is going on. Richards has also confirmed the determination of others regarding the solubility of calcium oxalate in water and found that 1 liter of boiling water dissolves over 1 centigram of oxalate. Hereby is shown the necessity for abandoning the practice followed by some chemists of long washing of the oxalate with excessive quantities of boiling water, though, of course, the rapid passing of wash-water through the filter would not extract the maxium amount of oxalate.

The old practice of determining water in rocks and many minerals by loss on ignition is now relegated to the garret for antiquated methods by all who can make any pretensions to careful work. As there is no rule without its exception, so here there are cases in which water can be estimated by loss on ignition with even greater certainty than by any direct method, but no such result can be accepted as above suspicion unless the composition of the body is otherwise known in great detail. The "loss" is often, especially in rock-work, the algebraic sum of several factors, some of which may have positive, others negative signs. Thus it quite often happens that, besides water, the loss is com-

pounded of one or more of the following factors: Carbon dioxide, sulphur or sulphur trioxide or both, hydrofluoric acid, silicon tetrafluoride, organic matter, nitrogen, helium, ammonia or ammoniacal salts, and even oxygen resulting from manganese dioxide, for instance. These losses may be offset by a gain of oxygen if fixed oxidizable substances are present, such as sulphides, and ferrous or manganous compounds, especially the carbonates. Of the above, the SiF_4 and the HFl result doubtless from chemical reaction at high temperatures in fluosilicates and hydrous fluorides respectively, the latter reaction being similar to that by which hydrochloric acid is given off on evaporating to dryness solutions of magnesium or aluminum chloride.

Again, it is now known that hydroxyl radicals cannot always be broken up in minerals with expulsion of water by the application of heat, even that of the blast-lamp, but that complete destruction of the molecule is essential. To the application of this discovery we owe our present knowledge of the composition of topaz and some other minerals, which contain not only fluorine but hydroxyl as well, undoubtedly in isomorphous replacement of each other.

Therefore, in order to avoid errors in determining water, it is now customary to fuse the mineral in a suitable apparatus with a flux—either sodium carbonate, lead or bismuth oxide, or borax, in order to prevent the loss of other constituents.

[At this point Gooch's tubulated crucible was exhibited and described.]

I spoke a moment ago of the replacement of fluorine by hydroxyl in some minerals. This was first perceived and pointed out by Penfield, who has done so much to clear away the mists surrounding the composition of many minerals. And it is by the recognition of this isomorphism of fluorine and hydroxyl, particularly, that hitherto inexplicable formulas have been made plain, and suspected but ill-understood relations have received rational explanation.

Many zeolites have long been known to give off a good deal of water below the boiling-point. This has ordinarily been held to be of a hygroscopic nature, despite the fact that

the curve showing the rate of loss suffered no abrupt change of direction at 100°, but continued to rise with increasing temperature. This made it extremely difficult to arive at any conclusions as to the number of molecules of water of crystallization that should be assigned to these minerals, no two analysts coming to quite the same conclusions, and the results representing often quite improbable fractions of molecules. The lately deceased Charles Friedel succeeded in explaining this peculiar behavior very satisfactorily by showing that this "zeolitic" water was not held as water of crystallization is supposed to be held, but more like that absorbed by a sponge; that some was still retained up to the temperature which disrupted the molecular net, and, that when cooled down again short of the attainment of this limit, the whole of the expelled water could be regained. Not only this, but that after expulsion of the water its place could be supplied by air, or ammonia gas, or carbon disulphide vapor, or alcohol vapor, etc., if the mineral were cooled down in the proper atmosphere, and that the amount absorbable is within certain limits a function of the vapor pressure. Thus we see that the water of some zeolites, at least that expelled at temperatures short of rupture of the molecular structure (often 10 to 18 per cent.), is no longer to be counted in the formula as water of crystallization.

In respect to the alkalies no marked changes in methods have been introduced beyond the convenient Gooch method for separating lithium from potassium and sodium in place of the old and unsatisfactory phosphate method. Gooch's method depends on the solubility in absolute amyl alcohol of lithium chloride and the insolubility of the other chlorides.

The most interesting novelty with reference to the determination of the SO_4 ion has connection with its precipitation as barium sulphate in presence of a ferric salt. This last, as you all know, is carried down with the barium apparently in the form of an insoluble complex sulphate, from which very serious errors result, which are greater in hot than in cold solutions. By operating in the cold, the formation of the ferric-sulphate ion-complex is so repressed

that fairly satisfactory results may be secured, but the best way is to avoid the possibility of their formation at all by removing its ferric ions from the solution before adding the barium chloride. This has long been done by the inconvenient method of fusing with an alkali carbonate and leaching with water. Far simpler is the procedure of Lunge, as modified by Küster and Thiel, whereby the iron is first precipitated by ammonia, then the SO_4 by barium chloride without first filtering, after which the iron is redissolved by hydrochloric acid and the barium sulphate left in pure condition.

For boron, we owe to Gooch and Rosenbladt independently a method which affords excellent results in the case of simple borates soluble in acids, but for some unexplained reason not always if they have first to be decomposed by fusion with an alkali. The method depends on expelling the boron as methyl borate by distilling with repeated portions of methyl alcohol the solution made slightly acid by nitric or acetic acid. The distillate is caught in a receiver containing slaked lime or ammonia. If the latter, this is later poured upon a known weight of slaked lime and the mixture is evaporated carefully and ignited over the blast. The increase gives the boric oxide.

For very small amounts of boron, however, the method is not available, and we unfortunately lack a method for its estimation in such cases.

The same may be said of glucinum, which is so little characterized by distinctive reactions capable of being made the basis for quantitative separations that we are as yet unable to detect this element in rocks with certainty. At least its detection is hampered by so many difficulties and uncertainties that the search for it is rarely undertaken. It and boron are certainly frequent constituents of some rocks, and convenient methods for their detection and isolation are much desired.

In a less degree this is true for fluorine, for whose separation we must still usually resort to the Berzelian method. When in quantity and not accompanied by phosphorus this old standby can afford fairly satisfactory results, but if the

amounts are small the difficulty of removing all traces of silica, etc., makes the results more or less approximate.

In the foregoing I have purposely confined myself largely to consideration of those processes of separation and determination which are of everyday or at least frequent occurrence in the work of the mineral chemist, and even of the technical chemist who works on inorganic lines—methods with which, in principle at least, many of you may be supposed to be well acquainted. To have touched even lightly upon special cases, as the assay of uranium and vanadium ores, the analysis of complex sulphides or unusual minerals of any sort, was quite out of the question. Even in what has been said, the subject has in no case been exhausted, nor have I been able to bring up all, even of the most important points that might have been touched upon. Enough has been said, I think, to show the general trend in analytical work toward the perfection and better understanding of old processes quite as much as the invention of new ones, and it is along this line that some of the best work has been done. As a further instance, I may mention the action of caustic alkalies on silica. It was long almost a principle of faith among mineral chemists that quartz was unaffected by solutions of the alkalies. How little foundation this belief had, the work of Lunge and Millberg has conclusively shown. From it, it appears that (given a sufficient degree of fineness) quartz powder is readily soluble, and that the solubility of silica in its different forms is but a function of its physical condition. Hence, methods for the determination of opaline silica in presence of quartz based on the solubility of the former in caustic-alkali solution can give at the best only approximate results, and these may be often totally wrong.

Enough has been said to show how far from being an exact art rock analysis is. It will, moreover, doubtless become more and more intricate as means are devised for detecting and estimating constituents which we now ignore or only suspect to exist in our material. But with these methods will come knowledge of the distribution of those elements such as has been already acquired with regard to

vanadium in rocks and to a less degree molybdenum. Thus, we know that with very siliceous igneous rocks it is usually unnecessary to look for vanadium, and in very basic ones for molybdenum. The same will be true in time for other elements, and our work will be lightened in degree as knowledge is gained of their relative abundance and distribution.

One of the most interesting problems confronting the mineralogist is that relating to the condition of nitrogen and helium in certain minerals, mostly those containing thorium and uranium—the two elements of highest atomic weight. It is because of the very high atomic weight of most of the metals in heliferous minerals that the relatively very small percentages of the light helium and nitrogen become of moment in the establishment of proper formulas for them. It seems very probable that these gases are not occluded, in the ordinary sense, but are in chemical combination, and if so, even two or three-tenths of one per cent. of helium must require for any sort of combination so large a weight of metal as to render vain any calculations from which it is omitted.

The search for and separation of small amounts and even traces of rock constituents is the most delicate part of rock analysis, and one which is calculated to tax to the utmost the ingenuity and patience of the conscientious worker. It is, I think, a feature of analytical work which might be cultivated with great profit in our educational laboratories. Oftentimes the methods applicable to the separation of very measurable amounts of various bodies refuse service or must be applied with special precautions when but traces of them are at hand, and this important knowledge the student seldom acquires as part of his regular instruction. I can conceive of no more valuable experience to an advanced student than a thorough initiation into the mysteries of a complex-rock analysis wherein not only the main components but all the lesser ones are carefully sought for and identified. This often involves considerable qualitative work of much value. There is, too, a satisfaction to be derived from the successful separation and identification of traces in a

complex mixture not inferior to that afforded by a clean separation of those same bodies in large amounts. By carefully carrying out such an analysis under competent guidance the student will acquire a fund of information that will broaden his ideas of chemical combinations and analytical research and be of more value to him than any one or several analytical investigations that I can think of. But the instruction should be thorough and should go into all the details of looking for traces and obtaining the proper corrections for any impurities that the weighed precipitates may ordinarly be expected to contain. Most instructors, it may be objected, do not have the time to acquire themselves the knowledge of detail needed for this work. But against this it may be said that every large educational institution can well enough afford an instructor who among his other specialties is versed in the intricacies of such work.

That knowledge of this kind is abundantly needed in many lines of work events have too often shown. He will be of greatest value in technical work who possesses knowledge beyond that of the immediate needs of oftentimes approximate commercial demands; for he, far better than the rule-of-thumb worker, will be able to recognize when his work goes wrong, which is often a far more difficult matter than to know when it is right.

SOLDERING WITH NASCENT BORAX.

In hard soldering with borax, direct, there are several little difficulties encountered that make the process somewhat difficult. In the first place the salt forms great bubbles in contact with the soldering-iron, and easily scales away from the surface of the parts to be soldered. Besides this, the parts must be carefully cleaned each time prior to applying the salt. All these difficulties vanish if instead of borax we use its component parts, boric acid and sodium carbonate. The heat of the soldering-iron acting on these causes them to combine in such a way as to produce an excellent flux, free from the difficulties mentioned.—*Drug. Circ. and Chem. Gaz.*

PHYSICAL SECTION.

Stated Meeting, held February 27, 1901.

On the Mathematical Theory of the Geometric Chuck.

By E. A. Partridge, Ph.D.

(*Concluded from p. 146.*)

Calling the instant at which p_1 and p_2 are simultaneously equal to zero, the zero point of time, we have the following expression for the rectangular co-ordinates of the point E at any time t.

$$x = e_1 \cos a_1 wt + e_2 \cos a_2 wt + e_3 \cos (p_3 + a_3 wt) + e_4 \cos (p_4 + a_4 wt) + e_5 \cos (p_5 + a_5 wt).$$

$$y = e_1 \sin a_1 wt + e_2 \sin a_2 wt + e_3 \sin (p_3 + a_3 wt) + e_4 \sin (p_4 + a_4 wt) + e_5 \sin (p_5 + a_5 wt).$$

The curves traced by the geometric chuck are all algebraic.

The v's are all integers or rational fractions; in the latter case the value of a_1 is necessarily chosen so as to make all the a's integers. Hence, we have the co-ordinates x and y expressed as the sum of sines and cosines of multiples of wt. The sines and cosines of multiple angles can be expressed as the sum of powers of the sine of the the simple angle affected with numerical coefficients. If the multiple is an even multiple of the simple angle, its sine can be expressed in powers of the sines with the factor $\cos wt$. If the multiple be odd, it can be expressed in powers of the sine without the cosine factor.

The cosine of an even multiple angle can be expressed as a sine of powers of sines simply affected by numerical coefficients, but if the multiple be odd in addition to numerical coefficients, we have the factor $\cos wt$. Then, in any case, by transposing all the terms affected by the factor $\cos wt$ to one side and squaring we can express x^2 and y^2 in terms of powers of $\sin wt$ and numerical coefficients.

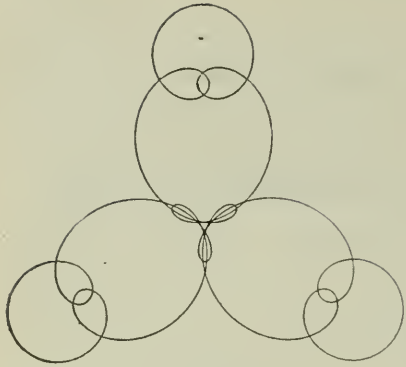

FIG. 19.

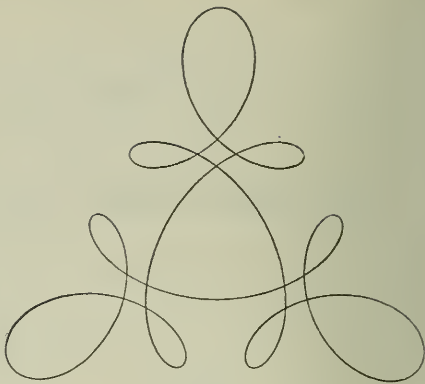

FIG. 20.

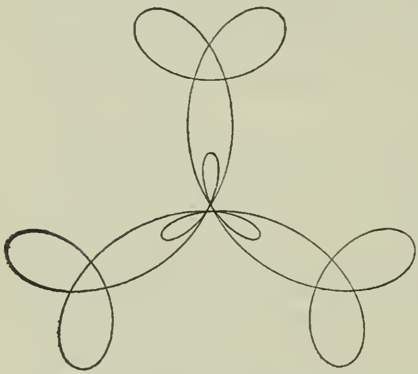

FIG. 21.

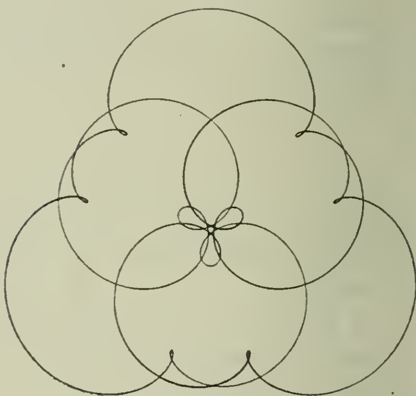

FIG. 22.

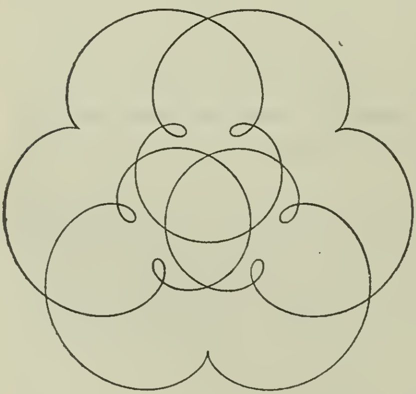

FIG. 23.

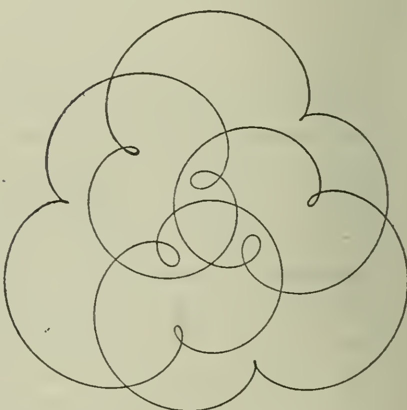

FIG. 24.

Then eliminating *sin wt* by the dialytic method we have an equation between x and y. Hence, the curves are all algebraic.

The curves traced by the geometric chuck are all of even order.

This follows from the fact that from the method of their generation they are all closed curves.

The deficiency of the geometric chuck curves is always zero.

It will, of course, be inferred, from the mode of generation, that the curves are unicursal, but the analytical demonstration is very simple. Having developed the parametric expressions for x and y in powers of *sin wt* with the factor *cos wt* make the following substitutions:

Let $$wt = 2\delta \qquad \text{and } \tan\delta = d$$

then $$\cos wt = \cos 2\delta = \frac{1 - \tan^2\delta}{1 + \tan^2\delta} = \frac{1 - d^2}{1 + d^2}$$

$$\sin wt = \sin 2\delta = \frac{2 \tan\delta}{1 + \tan_2\delta} = \frac{2d}{1 + d^2}$$

Since we have developed x and y in powers of *sin wt* and the factor *cos wt*, by substituting the above values for *sin wt* and *cos wt*, we have expressed x and y rationally in terms of a single parameter. Hence, the curves are unicursal. (Jordan: "Cours d'Analyse," Vol. I, §598, 599.)

The degree of the curves is $2n$ where n equals the greatest of the a's.

In the resultant of two equations the coefficients of each equation enter in the degree of the variable in the other. Hence, that which determines the degree of the resultant in x and y is the degree of the highest power of *sin wt* or the degree of the highest power of "d" after having made the substitution considered in the last paragraph. Now, the highest power of *sin wt* results from the highest multiple of wt; that is, the largest "a."

Suppose this largest $a = n$. If n is even, then the highest power of *sin wt* resulting from *sin nwt* will be the $(n - 1)$

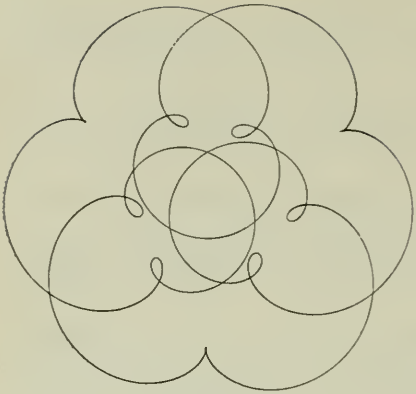

FIG. 25.

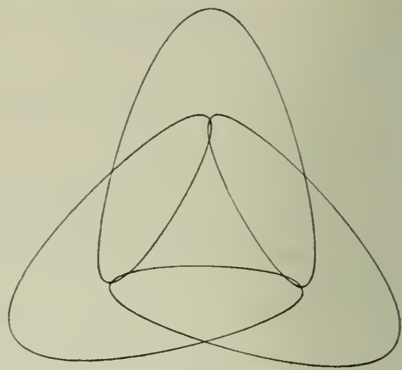

FIG. 26.

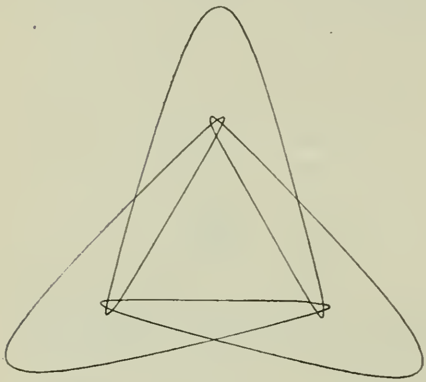

FIG. 27.

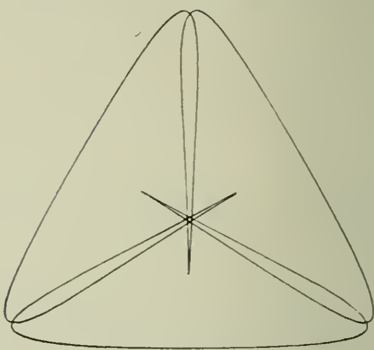

FIG. 28.

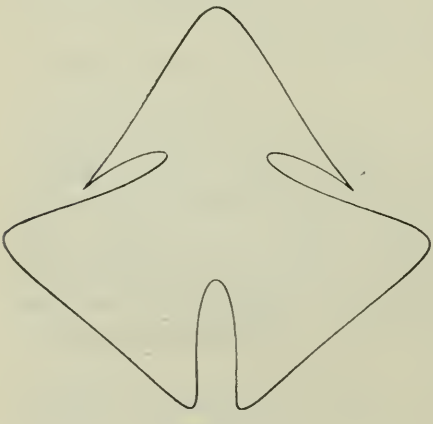

FIG. 29.

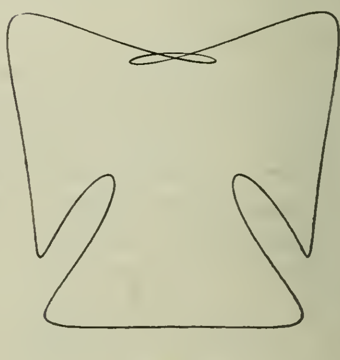

FIG. 30.

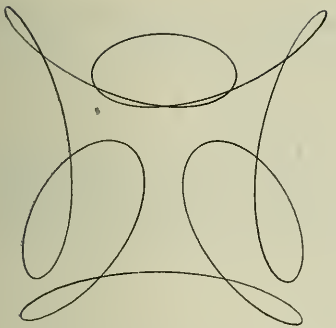

FIG. 31.

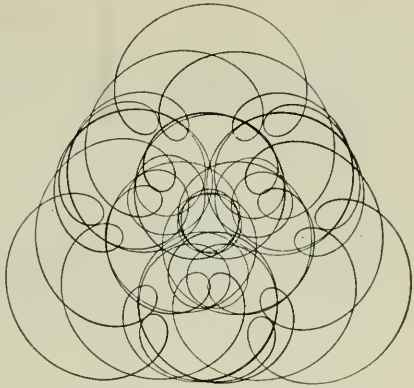

FIG. 32.

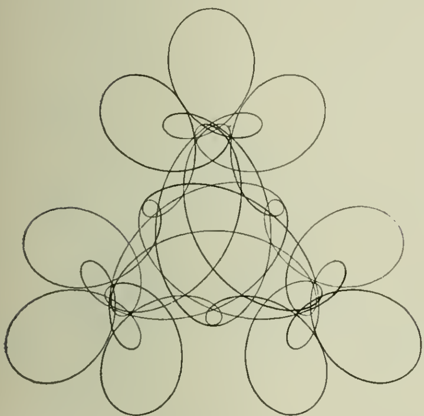

FIG. 33.

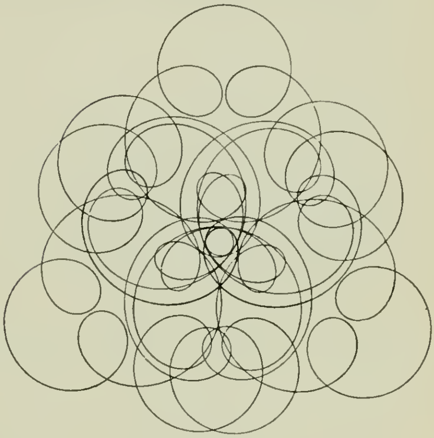

FIG. 34.

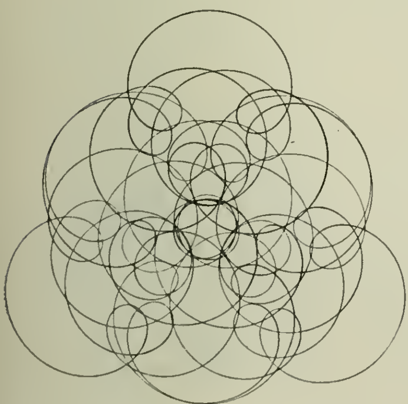

FIG. 35.

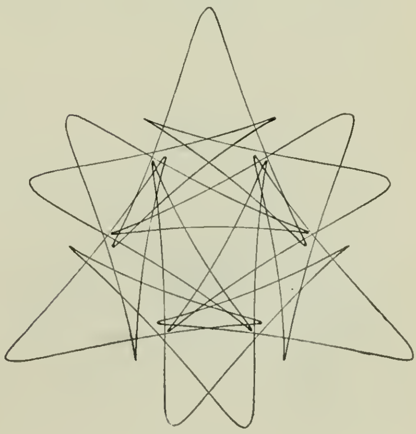

FIG. 36.

th, but it will be multiplied by the factor *cos wt*, so that substituting the above values we get

$$\left(\frac{2d}{1 + d^2}\right)^{n-1} \times \frac{1 - d^2}{1 + d^2},$$

in which expression the highest power of d is d^{2n}. The highest power of *sin wt* resulting from *cos nwt* is the *nth*, which gives on substitution

$$\left(\frac{2d}{1 + d^2}\right)^{n},$$

in which d^{2n} is the highest power of d.

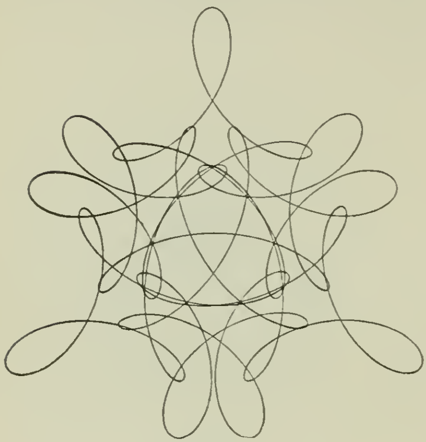

FIG. 37.

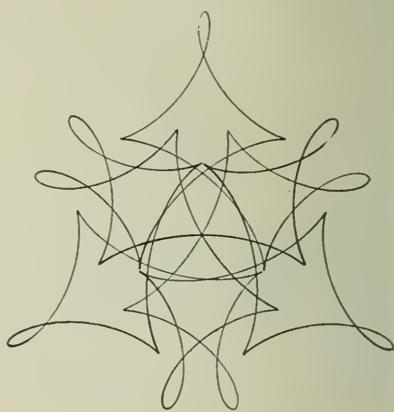

FIG. 38.

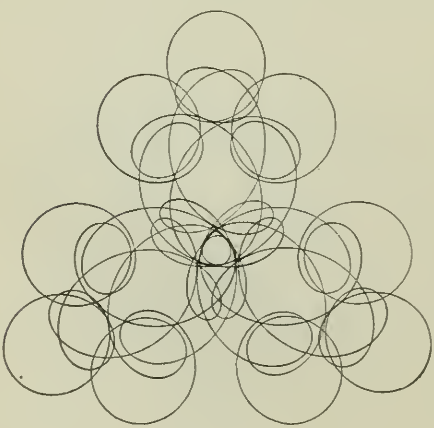

FIG. 39.

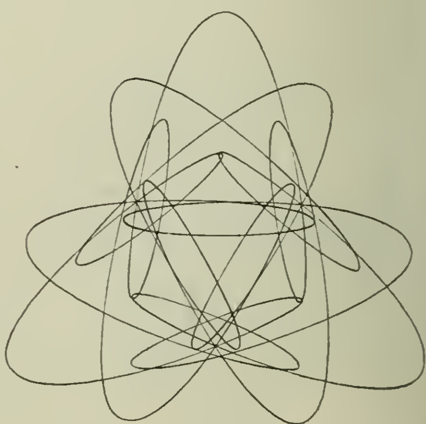

FIG. 40.

If n is odd, the highest power of $sin\ wt$ resulting from $sin\ nwt$ will be the n th, which gives on substitution

$$\left(\frac{2d}{1 + d^2}\right)^n.$$

The highest power of d is d^{2n}. The highest power of $sin\ wt$ resulting from $cos\ nwt$ is the $(n - 1)$ th with the factor $cos\ wt$. This term $sin^{n-1}\ wt\ cos\ wt$ gives the term

$$\left(\frac{2d}{1 + d^2}\right)^{n-1}\left(\frac{1 - d^2}{1 + d^2}\right)$$

in which the highest power of d is d^{2n}.

From the analysis we get the result that d^{2n} is the highest power of d under all circumstances.

The p's do not affect this at all, since on replacing $cos\ (p_3 + nwt)$ by its equivalent $cos\ p_3\ cos\ nwt - sin\ p_3\ sin\ nwt$, the above reasoning applies without modification.

As the denominators are all powers of $(1 + d^2)$ multiply the expression for x and y by $(1 + d^2)^{2n}$ and eliminate d by the dialytic method, and we get an equation in x and y of degree $2n$ in both x and y. Hence, the degree of the curves is $2n$ under all circumstances.

For the purpose of performing this development and elimination in actual cases I have calculated the numerical coefficients of the powers of $sin\ nx$ and $cos\ nx$ for all values of n up to 20. They accompany this paper in tabular form.

Another method of performing the elimination is to form the equation of the tangent to the curve, which is particularly easy by finding

$$\frac{dy}{dx}$$

by simple differentiation and inserting in the general equation of the tangent, and then finding the envelop of the tangent.

If for any purpose polar co-ordinates are required, they can be easily obtained by the following transformation:

(1) $x = e_1\ cos\ a\ wt +$ etc.

(2) $y = e_1\ sin\ a\ wt +$ etc.

$\rho\ cos\ \vartheta = x.$

$\rho\ sin\ \vartheta = y.$

Multiply (1) by $cos\ \vartheta$ and (2) by $sin\ \vartheta$ and add; we get $\rho = e_1\ cos\ a_1\ wt\ cos\ \vartheta + e_1\ sin\ a_1\ wt\ sin\ \vartheta$ + etc.

Multiply (1) by $sin\ \vartheta$ and (2) by $cos\ \vartheta$ and subtract; we get $o = e_1\ cos\ a_1\ wt\ sin\ \vartheta - e_1\ sin\ a_1\ wt\ cos\ \vartheta$ + etc.

Eliminating wt by any of the methods already described, we get an equation between ρ and ϑ.

In order to illustrate the beauty and variety of the curves drawn by the geometric chuck, and to render the preceding text clearer, I have drawn a number of curves which are appended to the paper.

The following is a description of the figures.

The first eighteen curves are produced by the combination of two circular motions. The equations comprising all of them are:

$x = e_1\ cos\ a_1\ wt + e_2\ cos\ a_2\ wt.$

$y = e_1\ sin\ a_1\ wt + e_2\ sin\ a_2\ wt.$

Fig. 1.	$v_1 =$ 1	$a_1 =$ 1	$a_2 =$ 2
		$e_1 =$ 1	$e_2 =$ ·5
Fig. 2.	$v_1 =$ 1	$a_1 =$ 1	$a_2 =$ 2
		$e_1 =$ ·5	$e_2 =$ ·8
Fig. 3.	$v_1 = +2$	$a_1 =$ 1	$a_2 =$ 3
		$e_2 =$ ·5	$e_2 =$ ·5
Fig. 4.	$v_1 = +2$	$a_1 =$ 1	$a_2 =$ 3
		$e_1 =$ ·5	$e_2 =$ ·8
Fig. 5.	$v_1 = -2$	$a_1 =$ 1	$a_2 = -1$
		$e_1 =$ ·5	$e_2 =$ ·8
Fig. 6.	$v_1 = -2$	$a_1 =$ 1	$a_2 = -1$
		$e_1 =$ ·5	$e_2 =$ ·5
Fig. 7.	$v_1 = +3$	$a_1 =$ 1	$a_2 =$ 4
		$e_1 =$ ·5	$e_2 =$ ·125
Fig. 8.	$v_1 = +3$	$a_1 =$ 1	$a_2 =$ 4
		$e_1 =$ ·5	$e_2 =$ .2
Fig. 9.	$v_1 = +3$	$a_1 =$ ·1	$a_2 =$ 4
		$e_1 =$ ·5	$e_2 =$ ·3
Fig. 10.	$v_1 = +3$	$a_1 =$ 1	$a_2 =$ 4
		$e_1 =$ ·5	$e_2 =$ ·4
Fig. 11.	$v_1 = +3$	$a_1 =$ 1	$a_2 =$ 4
		$e_1 =$ ·5	$e_2 =$ ·5
Fig. 12.	$v_1 = +3$	$a_1 =$ 1	$a_2 =$ 4
		$e_1 =$ ·5	$e_2 =$ 0

Fig. 13.	$v_1 = -3$	$a_1 = 1$	$a_2 = -2$
		$e_1 = {·5}$	$e_2 = {·1}$
Fig. 14.	$v_1 = -3$	$a_1 = 1$	$a_2 = -2$
		$e_1 = {·5}$	$e_2 = .2$
Fig. 15.	$v_1 = -3$	$a_1 = 1$	$a_2 = -2$
		$e_1 = {·5}$	$e_2 = {·25}$
Fig. 16.	$v_1 = -3$	$a_1 = 1$	$a_2 = -2$
		$e_1 = {·5}$	$e_2 = {·3}$
Fig. 17.	$v_1 = -3$	$a_1 = 1$	$a_2 = -2$
		$e_1 = {·5}$	$e_2 = {·4}$
Fig. 18.	$v_1 = -3$	$a_1 = 1$	$a_2 = -2$
		$e_1 = {·5}$	$e_2 = {·5}$

The curves shown in *Figs. 19* to *31* are formed by the composition of three circular motions. The general equations including them are:

$$x = e_1 \cos a_1 wt + e_2 \cos a_2 wt + e_3 \cos (p_3 + a_3 wt).$$
$$y = e_1 \sin a_1 wt + e_2 \sin a_2 wt + e_3 \sin (p_3 + a_3 wt).$$

Fig. 19.	$v_1 = +3$	$a_1 = 1$	$e_1 = {·5}$	
	$v_2 = +3$	$a_2 = 4$	$e_2 = {·5}$	$p_3 = 0$
		$e_3 = 13$	$e_3 = {·2}$	
Fig. 20.	$v_1 = +3$	$a_1 = 1$	$e_1 = {·5}$	
	$v_2 = -3$	$a_2 = 4$	$e_2 = {·5}$	$p_3 = 0$
		$a_3 = -5$	$e_3 = {·3}$	
Fig. 21.	$v_1 = +3$	$a_1 = 1$	$e_1 = {·5}$	
	$v_2 = -3$	$a_2 = 4$	$e_2 = {·5}$	$p_3 = 180°$
		$a_3 = -5$	$e_3 = {·3}$	
Fig. 22.	$v_1 = -3$	$a_1 = 1$	$e_1 = {·5}$	
	$v_2 = +3$	$a_2 = -2$	$e_2 = {·5}$	$p^3 = 0$
		$a_3 = -11$	$e_3 = .2$	
Fig. 23.	$v_1 = -3$	$a_1 = 1$	$e_1 = {·5}$	
	$v_2 = +3$	$a_2 = -2$	$e_2 = {·5}$	$p_3 = 15°$
		$a_3 = -11$	$e_3 = {·2}$	
Fig. 24.	$v_1 = -3$	$a_1 = 1$	$e_1 = {·5}$	
	$v_2 = +3$	$a_2 = -2$	$e_2 = {·5}$	$p_3 = 90$
		$a_3 = -11$	$e_3 = {·2}$	
Fig. 25.	$v_1 = -3$	$a_1 = 1$	$e_1 = {·5}$	
	$v_2 = +3$	$a_2 = -2$	$e_2 = {·5}$	$p_3 = 180°$
		$a_3 = -11$	$e_3 = {·2}$	
Fig. 26.	$v_1 = -3$	$a_1 = 1$	$e_1 = {·5}$	
	$v_2 = -3$	$a_2 = -2$	$e_2 = {·5}$	$p_3 = 0$
		$a_3 = +7$	$e_3 = {·2}$	

Fig. 27.	$v_1 = -3$	$a_1 = 1$	$e_1 = \cdot 5$	
	$v_2 = -3$	$a_2 = -2$	$e_2 = \cdot 5$	$p_3 = 0$
		$a_3 = +7$	$e_3 = \cdot 3$	
Fig. 28.	$v_1 = -3$	$a_1 = -1$	$e_1 = \cdot 5$	
	$v_2 = -3$	$a_2 = -2$	$e_2 = \cdot 5$	$p_3 = 180°$
		$a_3 = +7$	$e_3 = \cdot 3$	
Fig. 29.	$v_1 = -3$	$a_1 = 3$	$e_1 = \cdot 75$	
	$v_2 = -\frac{10}{3}$	$a_2 = -6$	$e_2 = \cdot 4$	$p_3 = 0$
		$a_3 = +24$	$e_3 = \cdot 17$	
Fig. 30.	$v_1 = -3$	$a_1 = 3$	$e_1 = \cdot 75$	
	$v_2 = -\frac{10}{3}$	$a_2 = -6$	$e_2 = \cdot 4$	$p_3 = 180°$
		$a_3 = +24$	$e_3 = \cdot 17$	
Fig. 31.	$v_1 = -3$	$a_1 = 3$	$e_1 = \cdot 75$	
	$v_2 = -\frac{10}{3}$	$a_2 = -6$	$e_2 = \cdot 4$	$p_3 = 0$
		$a_3 = +24$	$e_3 = \cdot 4$	

Figures 33 to 40 are curves formed by the combination of four circular motions. The general equations are: $x = e_1 \cos a_1 wt + e_2 \cos a_2 wt + e_3 \cos (a_2 wt + p_3) + e_4 \cos (a_4 wt + p_4)$; $y = e_1 \sin a_1 wt + e_2 \sin a_2 wt + e_3 \sin (a_2 wt + p_3) + e_4 \sin (a_4 wt + p_4)$.

Fig. 32.	$v_1 = +3$	$a_1 = 1$	$e_1 = \cdot 2$	
	$v_2 = +3$	$a_2 = 4$	$e_2 = \cdot 5$	$p_3 = 0$
	$v_3 = +3$	$a_3 = 13$	$e_3 = \cdot 5$	$p_4 = 0$
		$a_4 = 40$	$e_4 = \cdot 3$	
Fig. 33.	$v_1 = +3$	$a_1 = 1$	$e_1 = \cdot 2$	
	$v_2 = +3$	$a_2 = 4$	$e_2 = \cdot 5$	$p_3 = 0$
	$v_3 = -3$	$a_3 = 13$	$e_3 = \cdot 5$	$p_4 = 0$
		$a_4 = 14$	$e_4 = \cdot 3$	
Fig. 34.	$v_1 = +3$	$a_1 = 1$	$e_1 = \cdot 2$	
	$v_2 = -3$	$a_2 = 4$	$e_2 = \cdot 5$	$p_3 = 0$
	$a_3 = +3$	$a_3 = -5$	$e_3 = \cdot 5$	$p_4 = 0$
		$a_4 = -32$	$e_4 = \cdot 3$	
Fig. 35.	$v_1 = -3$	$a_1 = 1$	$e_1 = \cdot 2$	
	$v_2 = +3$	$a_2 = -2$	$e_2 = \cdot 5$	$p_3 = 0$
	$v_3 = +3$	$a_3 = -11$	$e_3 = \cdot 5$	$p_4 = 0$
		$a_4 = -38$	$e_4 = \cdot 3$	
Fig. 36.	$v_1 = +3$	$a_1 = 1$	$e_1 = \cdot 2$	
	$v_2 = -3$	$a_2 = 4$	$e_2 = \cdot 5$	$p_3 = 0$
	$v_3 = -3$	$a_3 = -5$	$e_3 = \cdot 5$	$p_4 = 0$
		$a_4 = 22$	$e_4 = \cdot 3$	

Sin $a =$	$\sin a$									
$2a = \cos a\,[$	$2 \sin a]$									
$3a =$	$3 \sin a$	$-4 \sin^3 a$								
$4a = \cos a\,[$	$4 \sin a$	$-8 \sin^3 a]$								
$5a =$	$5 \sin a$	$-20 \sin^3 a$	$+16 \sin^5 a$							
$6a = \cos a\,[$	6	-32	$+32\ ]$							
$7a =$	7	-56	$+112$	$-64 \sin^7 a$						
$8a = \cos a\,[$	8	-80	$+192$	$-128\ ]$						
$9a =$	9	-120	$+432$	-576	$+256 \sin^9 a$					
$10a = \cos a\,[$	10	-160	$+672$	-1024	$+512\ ]$					
$11a =$	11	-220	$+1232$	-2816	$+2816$	$-1024 \sin^{11} a$				
$12a = \cos a\,[$	12	-280	$+1792$	-4608	$+5120$	$-2048\ ]$				
$13a =$	13	-364	$+2912$	-9984	$+16640$	-13312	$+4096 \sin^{13} a$			
$14a = \cos a\,[$	14	-448	$+4032$	-12768	$+28160$	-24576	$+8192\ ]$			
$15a =$	15	-560	$+6048$	-28800	$+70400$	-92160	$+61440$	$-16384 \sin^{15} a$		
$16a = \cos a\,[$	16	-672	$+8064$	-42240	$+112640$	-159744	$+114688$	$-32768\ ]$		
$17a =$	17	-816	$+11424$	-71808	$+239360$	-452608	$+487424$	-278528	$+65536 \sin^{17} a$	
$18a = \cos a\,[$	18	-960	$+14784$	-101376	$+366080$	-745472	$+860160$	-524288	$+131072\ ]$	
$19a =$	19	-1140	$+20064$	-160512	$+695552$	-1770496	$+2723840$	-2490368	$+1245184$	$-262144 \sin^{19} a$
$20a = \cos a\,[$	20	-1320	$+25344$	-219648	$+1025024$	-27955[illegible]	$+4587520$	-4456448	$+2359296$	$-524288\ ]$

Cos $a = \cos a$											
$2a =$	1	$-2 \sin^2 a$									
$3a = \cos a\,[$	1	-4									
$4a =$	1	-8	$+8 \sin^4 a$								
$5a = \cos a\,[$	1	-12	$+16\ ]$								
$6a =$	1	-18	$+48$	$-32 \sin^6 a$							
$7a = \cos a\,[$	1	-24	$+80$	$-64\ ]$							
$8a =$	1	-32	$+160$	-256	$+128 \sin^8 a$						
$9a = \cos a\,[$	1	-40	$+240$	-448	$+256\ ]$						
$10a =$	1	-50	$+400$	-1120	$+1280$	$-512 \sin^{10} a$					
$11a = \cos a\,[$	1	-60	$+560$	-1792	$+2304$	$-1024\ ]$					
$12a =$	1	-72	$+840$	-3584	$+6912$	-6144	$+2048 \sin^{12} a$				
$13a = \cos a\,[$	1	-84	$+1120$	-5376	$+11520$	-11264	$+4096\ ]$				
$14a =$	1	-98	$+1568$	-9408	$+26880$	-39424	$+28672$	$-8192 \sin^{14} a$			
$15a = \cos a\,[$	1	-112	$+2016$	-13440	$+42240$	-67584	$+53248$	$-16384\ ]$			
$16a =$	1	-128	$+2688$	-21504	$+84480$	-180224	$+212992$	-131072	$+32768 \sin^{16} a$		
$17a = \cos a\,[$	1	-144	$+3360$	-29568	$+126720$	-292864	$+372736$	-245760	$+65536\ ]$		
$18a =$	1	-162	$+4320$	-44352	$+228096$	-658944	$+1118208$	-1105920	$+589824$	$-131072 \sin^{18} a$	
$19a = \cos a\,[$	1	-180	$+5280$	-59136	$+329472$	-1025024	$+1863680$	-1966080	$+1114112$	$-262144\ ]$	
$20a =$	1	-200	$+6600$	-84480	$+549120$	-2050048	$+4659200$	-6553600	$+5570560$	-2621440	$+524288 \sin^{20} a$

Fig. 37.	$v_1 = -3$	$a_1 = 1$	$e_1 = ·2$	
	$v_2 = +3$	$a_2 = -2$	$e_2 = ·5$	$p_3 = 0$
	$v_3 = -3$	$a_2 = -11$	$e_3 = ·5$	$p_4 = 0$
		$a_4 = 16$	$e_4 = ·3$	
Fig. 38.	$v_1 = -3$	$a_1 = 1$	$e_1 = ·2$	
	$v_2 = +3$	$a_2 = -2$	$e_2 = ·5$	$p_3 = 0$
	$v_3 = -3$	$a_3 = -11$	$e_3 = ·5$	$p_4 = 0$
		$a_4 = 16$	$e_4 = ·2$	
Fig. 39.	$v_1 = -3$	$a_1 = 1$	$e_1 = ·2$	
	$v_2 = -3$	$a_2 = -2$	$e_2 = ·5$	$p_3 = 0$
	$v_3 = +3$	$a_3 = 7$	$e_3 = ·5$	$p_4 = 0$
		$a_4 = 34$	$e_4 = ·3$	
Fig. 40.	$v_1 = -3$	$a_1 = 1$	$e_1 = ·2$	
	$v_2 = -3$	$a_2 = -2$	$e_2 = ·5$	$p_3 = 0$
	$v_3 = -3$	$a_3 = 7$	$e_3 = ·5$	$p_4 = 0$
		$a_4 = -20$	$e_4 = ·3$	

WIRELESS MESSAGES TO A MOVING TRAIN.

On the occasion of the recent Forty-seventh Annual Convention of the American Association of General Passenger and Ticket Agents, the Grand Trunk Railway gave a demonstration of wireless telegraphy on a moving train. The experiment was entirely successful.

The demonstration was made by Dr. E. Rutherford, F.R.S.C., and Dr. Howard T. Barnes, F.R S.C., both of the Macdonald Physical Laboratory of the McGill University, Montreal. Signals were exchanged between a station and a train (which was running at the rate of 50 miles an hour). No attempt was made to cover distances comparable in length with those attained by Marconi and others, but with comparatively simple laboratory apparatus it was possible to keep the train in touch with the station for from 8 to 10 miles. St. Dominique was selected as the transmitting station, where two large metal plate vibrators 10 x 12 feet, connected with an induction coil of the usual pattern, were situated. On the train itself the waves were received by collecting wires connected to a coherer of nickel and silver powder. The relay operated electric bells in three cars. The collecting wires were run through the guides for the train signal-cord, and extended on both sides of the coherer for about one car length. To obtain the maximum effect it would have been better to have had a long vertical wire, but since this was impossible, the horizontal wire was used. Although these were placed *inside* the steel frame cars, strong and definite signals were obtained over the distance named. Another difficulty militated against obtaining the maximum sensitiveness, as owing to the natural vibration of the train resulting from its great speed, it was impossible to have the relay adjusted to its most sensitive point. In spite of these difficulties the distance to which signals could be sent to the train was eminently satisfactory, and with more refined apparatus greater distances could, without doubt, be covered. The success of this form of wireless telegraphy, of which this was but a pioneer experiment, opens up yet another method of providing for the safety of the traveling public.—*Scientific American.*

PHYSICAL SECTION.

Stated Meeting, held Thursday, January 15, 1903.

A Relation between the Mean Speed of Stellar Motion and the Velocity of Wave Propagation in a Universal Gaseous Medium Bearing upon the Nature of the Ether.

By Luigi d'Auria.

In the *Philosophical Magazine* for August, 1901, Lord Kelvin pointed out that an infinite ether must of necessity be *imponderable;* that is, a substance outside the law of universal gravitation, leaving the alternative, however, that a gravitational ether may be admitted, occupying only a finite volume of space. Such an ether could exist only as an immense gaseous globe, and if w denotes the density of this globe at any distance z from the center; w_0 the mean density of the concentric sphere of elementary gas of radius z; S the distance which separates the solar system from the center of the universal gaseous globe; σ the density of the gas in this system; k the constant of gravitation; then, on the supposition that the gaseous globe is in equilibrium of temperature, so that the mean square speed u of the elements of matter throughout its volume is constant, we would have the equation

$$\tfrac{1}{3}\, u^2\, d\, w = \tfrac{4}{3}\, \pi\, z^3\, w_0 \times \frac{k\, w\, d\, z}{z^2},$$

or

$$\frac{d\, w}{w\, w_0} = \frac{4\, \pi\, k}{u^2}\, z\, d\, z. \quad (1)$$

In order to find a relation between w and w_0, assume that w varies inversely with some power n of the distance z; that is, put

$$w = \sigma \left(\frac{S}{z}\right)^n, \quad (2)$$

Then, the mass of a concentric spherical shell of gas of thickness $d\,z$ and radius z can be expressed by

$$4\,\pi\,\sigma\left(\frac{S}{z}\right)^{n} z^{2}\,d\,z,$$

and therefore we can put

$$\tfrac{4}{3}\,\pi\,z^{3}\,w_{0} = 4\,\pi\,\sigma\int_{0}^{z}\left(\frac{S}{z}\right)^{n} z^{2}\,d\,z,$$

from which

$$w_{0} = \frac{3}{3-n}\,\sigma\left(\frac{S}{z}\right)^{n} = \frac{3\,w}{3-n}. \quad (3)$$

Substituting this in (1) we can write

$$\int\frac{d\,w}{w^{2}} = \frac{3}{3-n}\times\frac{4\,\pi\,k}{u^{2}}\int z\,d\,z,$$

which gives

$$w = \frac{3-n}{6\,\pi\,k}\cdot\frac{u^{2}}{z^{2}}. \quad (4)$$

Comparing this expression for w with (2), we can easily conclude that $n = 2$, and therefore

$$w = \sigma\left(\frac{S}{z}\right)^{2}, \quad (5)$$

which shows that the density in the gaseous globe would not be uniform, but would vary inversely as the square of the distance from the center.

Substituting $n = 2$ in (3) and (4), we get

$$w_{0} = 3\,w; \quad (6)$$

$$w = \frac{u^{2}}{6\,\pi\,k\,z^{2}}; \quad (7)$$

and comparing (7) with (5), we get

$$\sigma = \frac{u^{2}}{6\,\pi\,k\,S^{2}} \quad (8)$$

and

$$u^{2} = 6\,\pi\,k\,S^{2}\,\sigma. \quad (9)$$

The mass of a concentric sphere of gas of radius z would be

$$\tfrac{4}{3}\,\pi\, z^3\, w_0 = 4\,\pi\, z^3\, w,$$

and observing that (5) gives $z^2\, w = S^2\, \sigma$, we can write

$$\tfrac{4}{3}\,\pi\, z^3\, w_0 = 4\,\pi\, S^2\, z\, \sigma.$$

Hence, the attraction of this sphere upon a unit mass at its surface would be

$$\varphi = \frac{4\,\pi\, k\, S^2\, \sigma}{z}. \quad (10)$$

Now, the centrifugal force which a unit mass acquires revolving with velocity v_0 in a circular orbit of radius z is v_0^2/z. Putting this equal to φ, we get

$$v^2_0 = 4\,\pi\, k\, S^2\, \sigma. \quad (11)$$

As this is independent of the distance z, we can conclude that all bodies moving in circular orbits around the center of the universe must have the same velocity.

Comparing (9) with (11), we get the simple relation

$$u^2 = \tfrac{3}{2}\, v_0^2. \quad (12)$$

Denoting by V the speed of propagation of a wave in the universal gaseous medium, we have also

$$V^2 = \tfrac{1}{3}\,\gamma\, u^2,$$

and putting $\gamma = 5/3$,

$$V^2 = \tfrac{5}{9}\, u^2. \quad (13)$$

Substituting for u its value (12), we get

$$V^2 = \tfrac{5}{6}\, v_0^2. \quad (14)$$

This relation shows that the speed of wave-propagation in a universal gaseous medium is not much greater than the velocity v_0, which velocity would be approximately equal to the mean speed of stellar motion. This, according to Kapteyn's investigation, appears to be about 19·3 miles per second, and therefore, according to our relation (14), the speed of wave-propagation in a universal gaseous medium could not be much greater than 17·6 miles per second.

This shows that such a medium would be utterly unfit to propagate energy with the velocity of light, and proves conclusively that the ether must be imponderable; that is, a substance outside the law of universal gravitation, whether the ether be infinite or finite.

Denoting by R and D the mean radius and the mean density of the earth, and by g the acceleration of gravity at the earth's surface, we can write

$$k = \frac{3\,g}{4\,\pi\,R\,D}$$

and substituting this in (8) and putting for u its value (12), we get

$$\sigma = \tfrac{1}{3}\,\frac{R\,D}{g}\left(\frac{v_0}{S}\right)^2. \quad (16)$$

If a plausible value could be assigned to S in this formula, then with the approximate value $v_0 = 19{\cdot}3$ miles per second, we could form an idea of the density which a universal gaseous medium would have in the solar system. Now, on the assumption of such a medium we would, according to our law of density (5), naturally expect to find the central regions of the universe occupied by a gas of considerable density, which would give us valid ground for assuming that in such regions only could the astonishing phenomena observed in *Nova Persei* take place. On this assumption we might use the distance of this star for the value of S, a distance which has been recently estimated to be about 159 light years, or $9{\cdot}36 \times 10^{14}$ miles.

Using this value for S and putting for R, D and g their numerical values, we get approximately

$$\sigma = 3{\cdot}9 \times 10^{-19}\,d, \quad (17)$$

in which d is the density of ordinary air. We have here a density which is of the same order of magnitude as that of ether, and which cannot be changed to any great extent by any reasonable change made in the values of S and v_0 assumed above. Indeed, we have good reasons to suppose that the solar system is rather near the center of the Milky

Way, and as this center would, according to our hypothesis, coincide with the center of the universe, the distance of 159 light years assumed for S is not too great, nor can it be very much smaller. Hence, the value of σ cannot deviate much from the value (17) and therefore there cannot be any objection raised against our hypothesis of a universal gaseous medium on the ground that it would oppose appreciable resistance to the motion of planets or other celestial bodies. It is true that the density of such a medium would be quite considerable in the vicinity of the center of the universe, but a simple calculation based upon our formula (16) will show that we would have to be within 585,000 miles of this center to find a density equal to that of ordinary air. The concentric sphere of the medium within a radius of 585,000 miles would have a mass about seven times that of the planet Jupiter, a mass entirely too small to be conspicuous in celestial space.

THE RUTHENBERG PROCESS AT LOCKPORT.

On Thursday, January 15th, a party of iron manufacturers visited the plant of the Cowles Electric Smelting and Aluminum Works at Lockport, N. Y., where there is installed what is erroneously called an electrical furnace. The apparatus is the invention of Marcus Ruthenberg, of Philadelphia, and really is capable of performing two functions—that of agglomerating or fritting fine ores, concentrates or flue-dust so as to put them into much better condition for charging into the blast furnace, or that of reducing the iron oxide to what may be termed a sponge, to be employed as a raw material in the open-hearth furnace. The apparatus consists of a horizontal horseshoe magnet hinged so that its poles may be approached. The poles are surrounded by water-cooled bronze rolls covered with carbon plates, which rotate in opposite directions. Along the lines of closest approach an electric arc is formed which subjects the material to be operated upon to a high temperature. The material is fed upon one of the rolls and is thus carried to the active zone, dropping out of the reach of its influence as the revolution of the roll carries the material beyond it.

The test of the apparatus last week was witnessed by John Fritz, of Bethlehem, Pa.; S. T. Wellman, of the Wellman-Seaver-Morgan Engineering Company, Cleveland, O.; W. J. Taylor, of the Taylor Iron and Steel Company, High Bridge, N. J.; Edwin Thomas, of Catasauqua, Pa.; J. K. McLanahan, of Hollidaysburg, Pa.; Frank Slocum, of the Jones & Laughlin Steel Company, Pittsburg, Pa., and J. B. Kraemer, of the Kittanning Iron Works.

A number of experiments were made. Among them was one with Lake Champlain magnetite concentrates, both alone and with an admixture of cast borings. When the ore does not possess magnetic properties to a certain degree Mr. Ruthenberg uses cast-iron borings in order to create the arc, the percentage varying with the circumstances. When putting the ore through the machine alone the action is sluggish and the capacity suffers. The result of this operation is a fritted material which is in much better shape mechanically for charging into the blast-furnace than the crude ore. Mr. Ruthenberg makes the important point that during the exposure of the ore to the action of the electric arc a considerable part of any sulphur in the ore is eliminated.

A somewhat more interesting operation is the direct reduction of iron-ore in the electric arc. The fine ore is mixed with carbon in a suitable form, and if desirable cast-iron borings are also added. Exposure of the mixture in the electric light causes a reduction of the iron oxide and there drops from the rolls a coarse, partly sintered material, which is largely iron in metallic form. This product is employed in the place of scrap in the open-hearth furnace, one charge having been made with it at a leading steel plant.

The rated capacity of the machine at Lockport is about 2½ to 3 tons of material per day of twenty hours, but we understand that a larger machine, with rolls three times as long, is being built which it is expected will reach a capacity of 10 tons per day. The electrical energy required for the Lockport machine is about 25 horse-power.—*Iron Age.*

THE USE OF OIL IN SMELTING.

The development of the oil industry has proved very beneficial to California, which, possessing no coal-fields of her own, has always been dependent upon Australia, Wyoming, Vancouver and Japan for her supply of the fuel employed in manufacturing and smelting. In its application to smelting the use of crude oil is a comparatively new departure. At the Selby works Mr. Alfred Von der Ropp has been very successful in this direction. He finds that a matting furnace, which ordinarily requires 1 ton of coal for every 3½ tons of ore, will smelt a ton of ore per barrel of oil, so that 3½ barrels of oil are the smelting equivalent of 1 ton of coal, in a locality where coal costs $6 per ton and fuel oil 80 cents per barrel. Under the prevailing conditions the use of oil represents an economy of 50 per cent.

Besides this economy of first cost, the oil fuel has been found advantageous because the oxidizing atmosphere of a roasting furnace can be maintained without those interruptions which take place when fresh coal is added—interruptions which are accompanied by the introduction of reducing gases which temporarily cause the process of oxidation to remain at a standstill. Moreover, it is possible with oil, by regulating the air inlet of the furnace, to control the smelting atmosphere so as to obtain oxidizing or reducing conditions, as the metallurgist may desire. The ability to increase the temperature of a metallurgical operation with notable ease is another good feature. It is an interesting example of adaptation to conditions, and the readiness with which it has been used is typical of that progressiveness which characterizes the energetic people of the West.—*Engineering and Mining Journal.*

THE FRANKLIN INSTITUTE.

A lecture delivered before the Franklin Institute and the Central Branch of the Young Men's Christian Association, Friday, November 21, 1902.

Two Years in Argentine as the Consulting Engineer of National Public Works.*

BY ELMER L. CORTHELL, SC.D.

MR. CHAIRMAN, LADIES AND GENTLEMEN: When, in the development of my program for about thirty-six lectures on Argentine to be given this coming winter and spring, I found it possible to select Philadelphia as the city in which to deliver the first of this series, I was very much pleased, for three reasons:

(1) Because it would be given before the Franklin Institute. I have always remembered with much satisfaction the lecture I gave about sixteen years ago before this Institute, and the appreciative and interested audience on that occasion.

(2) Because, being a founder and a sustaining member of a new branch of the Young Men's Christian Association recently established in Buenos Ayres, I was glad to know that this lecture is to be before an audience in which the Y.M.C.A. of Philadelphia would form a part jointly with that of the Franklin Institute.

(3) Because Philadelphia, as a city, and through its active association of manufacturers and commercial men, particularly through its Museum, has done and is doing more to open foreign markets to this country and promote reciprocal trade with other countries than any city in the United States.

In 1899 the Argentine Government, having conceived an extensive project of river and harbor improvement and made the preliminary surveys, requested the U. S. Govern-

* The lecture was profusely illustrated with the aid of lantern photographs.

ment to recommend an engineer who would come to Argentine and assist the Government by his advice in forming and executing the plans.

I had the honor of being selected for this position. After carrying out a two-years' contract with that Government, I have returned to my own country with some knowledge of the conditions and some experience in meeting them, which form the basis of this lecture.

At the final general session of the International Navigation Congress at Düsseldorf, July 4th, this last year, when called upon to respond for the Argentine Republic, I used the following words:

"It may not be out of place to make a few comparisons between the two countries, which by a singular coincidence I have the honor to represent—one as a delegate to this Congress, the other as a member of the Permanent International Commission. One of these countries is the Argentine Republic, and the other the United States of North America.

"Both are cosmopolitan; both have been populated largely from Europe; both had the task of supplanting savagery by civilization. The red races in each case had to give way to the Caucasian, or be assimilated with it. Both have great plains and immense river systems. The greatest river valley of the one is almost exactly equal to that of the other. Similar causes have produced nearly similar hydraulic conditions in each case. Both countries have temperate climates; both great mountain ranges; both some extent of arid lands and running waters for irrigation; both immense areas of rich soils, made so by similar beneficent causes; both have extensive pasture lands and millions of cattle, sheep and horses. In their cereals they are competitors with each other in the food markets of Europe—one is great and ambitious; the other, smaller, but earnestly devoted to progress, and ambitious to fulfil its high destiny among the nations of the earth."

By comparisons of the unknown with the known we appreciate and learn, and for that reason I shall compare Argentine with the United States in respect to some of its

more important features, and you will see that the two great countries have much in common.

You must, if possible, imagine yourselves in a situation exactly opposite from yours in the United States in regard to the sun and the poles of the earth; you must look north for warm winds and south for cold ones. Your winter will begin in June and your summer in December. The north side of your house will be sunny and the south side in the shade. As you travel north from Buenos Ayres, the capital, it will grow warmer; as you go south you will at last reach the glaciers. Your North Star will be changed to the Southern Cross, and in all these changes you will at first be lost. You must also locate yourself geographically, and recollect that the northern line of Argentine is in about the same latitude south of the Equator as Havana is north of it, and that the southern limit of Argentine corresponds to Labrador and Kamscatka, and that Buenos Ayres, Capetown and Melbourne are all in about the same latitude. Also that there are east and west differences. Buenos Ayres is in about the same longitude as Cape Breton Island, east of Nova Scotia; and the circle of longitude along the most westerly boundary of Argentine nearly passes through New York City, and the course from the entrance of the River Plata to Liverpool is nearly a straight line. In order that the location of Argentine in reference to other South American countries may be appreciated, it should be stated that Buenos Ayres is as far south of, say, Caracas, the present center of revolutionary and unstable South America, as the north end of Lake Winnipeg, in Manitoba, is north of Caracas, or as far as the northern part of Greenland is north of New Orleans.

With this orientation of ourselves on the Western Hemisphere, and with these remarkable differences in position, let me call your attention to a very remarkable similarity wherein will be seen and appreciated the beneficent work of the Great Creator long before at least the present race of mankind inhabited the two continents.

In a paper read before the American Association for the Advancement of Science, at Buffalo, August 5, 1896, upon

the delta of the Mississippi, I described the ancient conditions of that great river in substance as follows:

(1) A deep shore-line of the Gulf of Mexico when the site of Galveston was far out in the waters and the coast was 100 miles inland from the site of New Orleans—a wide and deep estuary 1,000 miles long, reaching into the heart of the continent to between St. Louis and Cairo, where, at Cape Giradeau, it met the ridge of the Ozark Mountains, stretching across the valley and holding back the ancient great lake, which covered Chicago 100 feet deep and spread over all the Prairie States and received and distributed over its bed the immense sediments of the Missouri and other great rivers in the North. (2) The cyclic change, lifting Florida out of the water and turning continental drainage north, cutting its way through the alluvion to Hudson Bay. (3) The breaking down of the Ozark barrier; the draining of the submerged area; the subsequent filling of the estuary and the advance of the alluvial lands into the Gulf to their present line, 110 miles beyond New Orleans. A great and wonderful beneficence for the use and convenience of man by the Great Architect of the universe.

Had not my engineering experience upon the Mississippi River and its delta drawn my attention to this extremely interesting ancient history of the great river of North America, I might not have been so deeply impressed by its remarkable similarity with that of the Paraná River in South America; and for both histories I am indebted to engineering investigators: General Warren, in the first instance, and Col. Geo. Earl Church, an American engineer living in London, in the second instance, the latter probably better acquainted by personal contact with the geography and hydraulics of south America than any living man.

I am indebted to him and the Royal Geographic Society, of which he is a director and a correspondent, for most of what follows in relation to this *ancient* history of the great rivers of Argentine and Central South America.

There are four great breaks in the mountained-fringed continent which we may call its great commercial doorways: The Orinoco, the Amazon, the La Plata and the deep inden-

tation of Bahia Blanca—one in Venezuela, one in Brazil and two in Argentine. The three river basins occupy two-thirds of the entire area of South America.

The two with which we are most interested in this lecture are the La Plata and Amazon, which have areas respectively of about 1,200,000 square miles and 2,722,000. But if we deduct from the latter the valley of the Tocantins, which has no direct connection with it, the valley of the Amazon is only 2,368,000 square miles, of which its principal branch, the Madeira, has a volume of discharge nearly equal to the Amazon itself, and at the falls, which I shall refer to later, it carries annually a volume equal to that of the La Plata, which has a minimum flow of about 534,000 cubic feet per second and a maximum of over 2,000,000—a river nearly double the size of the Mississippi (the Father of Waters), if we compare their mean annual discharges, the former being about 288 cubic miles and the latter 156 cubic miles. The Paraná ("the Mother of the Sea" in Indian language), the principal affluent of the La Plata, is itself 46 per cent. larger than the Mississippi, its mean annual discharge being about 230 cubic miles.

What a river the La Plata must have been in ancient times, when it had a maximum discharge of 4,000,000 cubic feet per second, well up toward the modern Amazon, estimated to be 5,297,000, and greater than the ancient Amazon!

I have described the ancient conditions of the Mississippi; the Gulf of Mexico as a great estuary and a deep shoreline extending well into the heart of the North American Continent. The same conditions existed in the contour line of South America in the La Plata estuary. It extended 1,400 miles into the continent and was 400 miles wide—eleven times greater than the Empire State. It was the great Pampean Sea, receiving the drainage not only of the present Paraná and its tributaries, but of the great Madeira River with its immense discharge of waters and sedimentary matters, the source of great alluvial formations, discharging into a sea two-thirds the size of the Mediterranean.

When, in the processes of Nature, the great underwater plains of rich soil had been formed during the comparatively

short period of less than 100,000 years, a dam was thrown across the Madeira by the rivers Grande and Parapití coming down from the Andes, and a deposit of more than 170 feet deep occurred, forming this dam, which produced the ancient Lake Mojos, with an area of about 115,000 square miles—larger than that of the great lakes of North America combined, which is less than 94,000.

The remarkable action of these rivers and the changes caused by it are graphically told by Colonel Church in his paper upon "Argentine Geography and the Ancient Pampean Sea."

"The Grande and the Parapití entered the plain with a northern trend to contest with the great river of the north the possession of the gap. They struck it almost at a right angle, and slowly pushed their rival eastward over against the Chaco base of the Chiquitos Sierras. Here the final conflict must have taken place, as the Grande and Parapití threw their dam across the outlet of the Mojos River, thus cutting off its exit into the ancient sea. No doubt the giant stream waged fierce war for thousands of years to keep its channel open, alternately sweeping away the barrier and again yielding to the ceaseless volume of sand and clay, which, visible to-day, confirms the victory of the Grande and Parapití. The dam having finally become permanent, the formation of the ancient Mojos Lake was assured. When it reached the level of the lip of Guajará-mirim, its waters commenced to tumble over it and carve their way to the Amazon. Since then, huge volumes of alluvium have poured down the northern slopes of the Bolivian Andes. The ancient lake is now almost loaded with material, but is not yet entirely obliterated. The muddy silt which covers the surface of the basin is so fine, that when an Indian goes up-stream to the mountains his friends ask him to bring back a stone that they may see what it is like.

"Since forming the dam, the Rio Grande has slowly been returning westward down the counterslope which its own alluvium creates."

During the process we have described, the ancient lake

and the Pampean Sea were connected, and their relation was similar to that of the Black Sea and Mediterranean. Traces of it are still observable, notably the great low-flooded morass of Xarayes on the upper Paraguay River, and the ancient delta of the Paraná, including the Ybará lagoon. The Salina Grande was also an arm of it—a great inland fiord. The sea, moreover, must have covered large areas of Paraguay, Corrientes, Entre Rios and Uruguay, and before the uplifting of the country it extended southwest to the rivers of Chadi-Leofu and the Colorado, lapping round the southern slope of the Ventana Range, until the curved rim, concave to the northeast, which connects this with the Sierra de Cordova, was sufficiently elevated to completely cut off its southwestern extension.

This range was high enough to lodge the glacial rocks coming from the Andes, one of which at Tandil is so poised and delicately balanced that the hand can rock it, but it cannot be dislodged. This range later prevented the entrance of the destructive sea, protecting the great area from its waves.

Then came another factor into the beneficent problem of the Creator. Instead of draining the waters from the great deposits under the Pampean Sea, as He did in North America, He lifted the Andes higher, and with them their atlantic slopes, until the latter were ultimately lifted to their present level, forming the "Plains of the Pampas," the soil of which is 50 feet deep and of surpassing richness —an area of 600,000 square miles—one-fifth the size of the United States and five times that of Great Britain. Thus by cyclic changes in the Northern Hemisphere, and by fluvial and sedimentary action and seismic changes in the Southern Hemisphere, have been formed the great interior agricultural regions of the United States and Argentina.

Let me now quote from Mr. Revy's work on "Hydraulics of Great Rivers" (Argentine rivers which he surveyed) where he compares the rivers as we now find them with others well known.

"Great as the volume of the Paraná River at its lowest summer level is—immense in comparison to the largest

European river, and much larger than that of all the European rivers put together—it is but a small fraction of its flood-volume during exceptional rises; and we can only wonder at the magnitude of the sources, which for months, nay, for whole years together pour forth inconceivable masses of sweet water, every drop of which had been raised by the power of the sun from the Pacific and Atlantic Oceans above the tops of the highest mountains of Brazil and the Andes.

"To convey an idea of the magnitude of the rivers which have been considered and analyzed in the preceding chapters, we have shown on Plate V several of the larger known rivers, such as the Danube and Thames of Europe, and the Mississippi of North America. They are all drawn to the same scale, and their relative size may somewhat be appreciated. The Mississippi is not unlike the Uruguay in dimensions and other features—we have similarity in width, depth, currents and fall, although the North American is the larger of the two. Comparing, however, the Paraná with the Mississippi, the former might claim the latter as his eccentric daughter under fourteen. The low-water dimensions measure a river's greatness, although things of different natures and character do not bear strict comparison. What we, however, understand by greatness is possessed in an exceptional degree by the Paraná."

In order, further, to compare the Paraná River with others, it may be stated that its annual flow is double that of the Ganges, three times that of the Saint Lawrence, four times that of the Danube and five times that of the Nile. We have records of *608 cubic miles* in one year; the mean being 288 and that of the Mississippi 156.

There are differing conditions of importance between the Paraná and the Mississippi, explaining the causes of the greater discharge of the Paraná. While they both flow south, one flows from colder to warmer, and the other from warmer to colder regions; and it is in the warmer regions in both cases that the rainfall is the greater. On the Mississippi, in the northern regions, where we find the greatest drainage area, the rainfall is about 35 inches per annum; in

the southern, where the area is less, the rainfall is 60 inches per annum. With the Paraná there is a rainfall of about 60 inches in the northern part, where the drainage area is greater, and about 40 inches in the southern part, where it is less.

The length of the Paraná River is about 3,000 miles; its navigable length, between Cuyabá in the north and the mouth of the Paraná in the delta of the La Plata, is 1,825 miles. The Uruguay River, from San Javier to the delta of the La Plata, has a navigable length of 603 miles. The Paraná River is made up of the two important rivers which unite at the city of Corrientes: the Paraguay and the Alto Paraná. The length of the latter above Corrientes, to the falls of the Iguazú, is 365 miles, and it is navigable nearly to that point. These wondrous falls excel in beauty, as well as exceed in dimensions, the Niagara Falls.

The latter are 160 feet high and four-fifths of a mile long, including Goat Island. The Iguazú are 213 feet high in one leap and 106 feet each in two leaps, and 2⅓ miles long with, at times, an immense volume of water.

The view before you is from a painting by a well-known Bern painter, Mr. Methfessel, who was engaged to come to Argentine, visit the Falls and make a large painting for the La Plata Museum.

The gorgeous and varicolored foliage of the luxuriant subtropical vegetation, which abounds on all sides, adds a charm to the Falls. They rank among the most beautiful and wonderful works of the Creator.

The remolinos, or whirlpools, below the Falls equal the famous whirlpool at Niagara.

The Uruguay is an entirely different river, in every respect, from the Paraná. It is at times a mighty river rivaling the Paraná; at others, it sinks into comparative insignificance. The Paraná is a great river at all times.

"The Paraná is a type of a truly great river; the Uruguay represents a mighty torrent of extraordinary dimensions."

The Uruguay rises near the Atlantic Seaboard in Brazil, in the Sierra del Mar, then runs west to the highlands of the

territory of Misiones. These highlands prevent it from uniting with the Alto Paraná River at that point, which is only about 68 miles distant. Along 600 miles of its course, from San Javier to Concordia, the bed of the river is filled with rocky ridges which, at low water, prevent any navigation, but during the floods, which are quite sudden but not long continued, the river is everywhere navigable. The river rises in floods at Concordia about 46 feet. Compared with the Paraná, it is a clear stream, carrying very little sediment in suspension. The Paraná is an entirely different river. Its source being in the tropical and rainy region of Brazil, on the flanks of the Andes, its floods are much longer continued. At the confluence of the Paraná and the Alto Paraná, at Corrientes, the rise of the floods is about 33 feet; at Rosario, 225 miles above Buenos Ayres, it is from 19·7 to 23 feet or 23½ feet in extreme floods. When these occur, the river is about 23 miles wide, covering the entire country with a depth of 6½ to 10 feet.

The physical characteristics of the bed of the river are, consequently, entirely different from those of the Uruguay; the bed of the latter is stable, that of the former very unstable. The sedimentary matters carried in suspension, however, are very much less than those of the Mississippi; probably only one-tenth of the amount carried in the Mississippi in times of flood. For this reason, the changes in the bed and banks are less radical; the most notable change is the movement of the islands and bars down-stream. For example, the Island of Espinillo, in front of the City of Rosario, lying in the middle of the river and about 2½ miles long, has moved flanking down-stream about 2½ miles in the last fifty years, and by this movement the advancing bar of the island has approached the river bank in front of Rosario and closed up the navigation channel.

The maximum velocity in great floods often reaches 6½ feet per second, although usually it is much less.

Both rivers are susceptible of improvement by dredging, the one to Asunción, which is 842 miles above the mouth, and the second to Concordia, which is 230 miles above its mouth. In the Paraná there is nothing but sand to be

removed throughout its entire length; in the Uruguay there are several places where it is necessary to remove rock and gravel. But, generally, the channel can be deepened by hydraulic or suction dredging.

The National Government is under obligation, by the law passed by Congress for building the Port of Rosario, to make and maintain a depth of 21 feet at low water in the Paraná River from the head of the Delta to Rosario, and in the Delta of the La Plata to Buenos Ayres, a depth of 19 feet at low water, which is about 21 feet at mean high tide. It has been proposed to make and maintain a channel of the following dimensions: From the mouth of the two rivers at the Island of Martin Garcia, at the head of the La Plata estuary, to Rosario, a depth of 21 feet and a width of 328 feet; Rosario to Santa Fé, 292 miles above Martin Garcia, 19 feet deep and 328 feet wide; Santa Fé to Corrientes, 10 feet deep. Santa Fé, or its seaport Colastiné, is the head of ocean navigation; above that point it is river navigation by steamboats.

On the Uruguay River it is proposed to make a channel 19 feet deep and 328 feet wide, from Martin Garcia to Concepcion del Uruguay, 137 miles above Martin Garcia, and thence 15 feet deep to Colon, and 9 feet deep and 8 feet over the rock to Concordia, which is 230 miles above Martin Garcia.

The low-water plane, or zero, in both rivers is that of extraordinary low water, so that, generally, the low water does not reach this plane within about ½ a meter to 1 meter; consequently, there can generally be depended upon from 2 to 3 feet more water than I have stated. Between Rosario and Buenos Ayres there are now no bars over which there is not 21 feet of water at 0, although two of them need to be dredged and buoyed in order to make a straighter channel. This the Government is prepared to do.

As to the port of Rosario, a contract has recently been made under the law of Congress to make a modern seaport at this point, with all the latest and best facilities for handling cargo. The commerce of Rosario is at present 1,500,000 tons per annum. It is a very important exporting point for

cereals, and when the port is completed, according to the plans adopted, it is expected to be an important importing port as well. There are ports below Rosario, such as Villa Constitución, San Nicolas and San Pedro, and above Rosario, Diamante, Santa Fé, Colastiné and Paraná. On the Uruguay River, Concordia, at the head of steamboat navigation, is an important importing and exporting place for that section of the country. Its registered tonnage is about 500,000 tons, and the actual weight tonnage about 100,000.

The country between the Paraná and Uruguay Rivers is practically isolated from the rest of the country, and its situation is very similar to the country lying between the Euphrates and the Tigris; for that reason it has been called the "Mesopotamia Argentina."

There are at present in that area three railroad systems—the Argentine Northeastern, which runs from Corrientes, on the Paraná, to Monte Caseros, on the Uruguay, and from there to Santo Tomé on the same river; the Argentine Eastern from Monte Caseros to Concordia; and the Entre Rios Railroad, the main line of which connects Paraná and Concepcion del Uruguay, with branches to Victoria, Gualeguay, Gualeguaychú and Villaguay. Within a few months a connecting line will be extended to Concordia, forming a link between the Argentine Eastern and the Entre Rios Systems. It has been proposed to unite these three systems and to extend the Argentine Northeastern from Santo Tomé to Posadas on the Alto Paraná, passing through the colonies which the Government is establishing in that territory. Posadas is its capital. The Central Paraguayan Railroad, which runs in a southeasterly direction from Asunción, it is proposed to extend to Villa Encarnación, a small town on the opposite side of the river from Posadas; to change the gage, which is 5½ feet, to the normal gage of the other three railroads, which is 4 feet 8½ inches; make a transfer by car float at Posadas; extend the Entre Rios Railroads to a port of deep water, either on the Paraná or Uruguay, and do a "through" business between Asunción and this new seaport, which will be only a few hours distant from Buenos Ayres.

With the Paraná River improved to Asunción, and the Uruguay improved to Concordia; with the railway systems united and extended to a good seaport, this great interior district of the country will have an ideal system of transportation, and the shipper can take his choice to ship by rail or by water, thus establishing a very useful and reasonable competition between water and railway, to the great advantage of the people.

In reference to the Rio de la Plata itself, it is an immense shoal estuary. It is the depositing ground of the great Paraná River. This estuary, in a not very remote period, extended above Santa Fé; this is shown by the comparison of old maps, of which ninety-two have been collected and copied and placed in the Library of the Ministry of Public Works. These maps date from the year 1529 to 1885. Even in this comparatively short period, remarkable changes are shown in the Delta of the Paraná, which is now a true delta, almost exactly in the form of the Greek letter Δ. It is 40 miles across its face; it slowly extends itself in the head of the estuary, and through the delta nearly a dozen outlets of the Paraná River find their way. It is very much like the deltas of the Danube, Ganges and Mississippi.

The superficial extension of the Rio de la Plata exceeds 18,000 square miles—larger than Switzerland; it is about 186 miles long and varies in width from 186 miles at the ocean, between Capes San Antonio and Santa Maria, to 1·12 miles at the extreme point of the head of the estuary, at Punta Gorda.

To understand the physical conditions of the estuary, it is necessary to divide the Rio de la Plata into Superior and Inferior, or upper and lower. The Rio de la Plata Superior lies above a line extending between La Plata and Colonia, the Inferior below that line to the sea. Over a distance of about 25 to 30 miles between Martin Garcia and the anchorage of Buenos Ayres, there is a normal depth through the best channels of from 16 to 20 feet at low water.

The National Government has recently completed the dredging over the San Pedro bar lying in this region,

increasing the depth of $18\frac{1}{2}$ feet to 21 feet, where there was formerly only 15 feet. In the Canal de las Limetas, or Nuevo Canal, by the natural forces and by the constant movement of steamers, there has been obtained a depth of about $19\frac{1}{2}$ feet, or $21\frac{1}{2}$ feet at mean high tide. Opposite Farallon, a rocky point on the Uruguay shore and opposite Buenos Ayres, there is, along the course of navigation, about $19\frac{1}{2}$ feet at low water. The Government has buoyed with luminous buoys the entire route from Buenos Ayres to the mouths of the Paraná River, the Bravo and the Guazú, and has placed a floating semaphore below Martin Garcia for the benefit of navigation, recording constantly by signals by day and by night the depth of water in the channel. It is now proposing to connect this semaphore by a telephone cable with the telegraph cable of Martin Garcia, so that communication may be established between the ships lying at anchor (waiting for the tide) or passing near the semaphore, with the offices of the agents at Buenos Ayres or Montevideo.

A careful study of the different conditions in the delta of the La Plata shows that the only method of improvement in such a vast expanse of water is by dredging and buoying the best channels.

In the lower Rio de la Plata there are very serious conditions. A bar on which there is a least depth of 20 feet at low tide lies between the anchorage of Buenos Ayres and Montevideo; the material in this bar is very soft and vessels plow their way through it at ordinary tides; but the great extent of the bar is the serious condition. Between the 24 feet curves, straight through this bar, there is a distance of 24 sea miles. To make a channel by dredging would require the removal of probably from 10,500,000 to 13,000,000 cubic yards; and it is very doubtful if, on such a broad extension of water and in such soft material, a channel could be maintained. But it is hoped that the plan now proposed of anchoring five lightships in the line of navigation, and in the direction of the current, and which can be seen from each other, will have an effect upon the bar by the continual movement of deep steamers through

it. The examination of the Rio de la Plata Inferior has been intrusted by the Government to the Ministry of Marine, which is making very extensive surveys and examinations over the entire area.

The estuary at this point is 46 miles wide, and five high towers on shore and others anchored within the area to be surveyed are necessary in order to cover this great Punta Indio bank.

These are the general physical conditions of the Rio de la Plata and its great tributaries.

The very important project of making a deeper channel of access to the Port of Buenos Ayres and enlarging the port to give it not only greater area and more facilities but greater depth in the enlarged part, is now before the Government, and the plans for it (made by myself) have been approved. There are alternative projects to meet the commercial necessities of the country: one is to deepen the present Port of La Plata and endow it with more facilities, where vessels drawing 24 or 25 feet may come in and go out at any stage of the tide; or to build a deep water port with a depth of not less than 30 feet on the seaboard outside of the difficult conditions of the Rio de la Plata. A concession has been granted and the project submitted to the National Government for an artificial port in the Great Bay of Samborombon, which is almost opposite Montevideo, and another concession for a port at Mar Chiquita, near Mar del Plata on the ocean, has also been granted.

In addition to the great drainage basin of the La Plata, there is farther south the large rivers, Rio Negro and Colorado, which, combined, have a drainage area of 464,000 square miles. The channels are not susceptible of improvement for a large commerce, but they will in the future furnish water for an extensive irrigation and steamboat navigation.

The hydraulic conditions are great, but the mountains are greater, and have exerted a powerful influence on the continent, not only its climate and its running waters but upon mankind. On these lofty table-lands lived the Incas and flourished their great empires. Among the clouds have

fought for supremacy the Incas troops and the Spanish soldiers, and here, too, have the struggles for liberty taken place; here Bolivar and San Martin led their troops to victory and continental freedom from the domination of Spain.

An orographic map of South America will show what immense areas are given up to mountain ranges and lofty summits. In their widest part the Andes are 500 miles in breadth. Some mighty force seems to have pushed them and the entire continental line eastward and massed the ranges into a complex system of mountains, towering isolated peaks, and parallel, transverse and interlaced ridges without number. In Bolivia, not far north of the country we are describing, there are thirty-two peaks above 17,000 feet high, some of them reaching over 21,000 feet; and in Argentine is the lofty Aconcagua lifting its solitary crown to an elevation of 23,080 feet, rivaling the loftiest mountains of the world. And Famatina, in the Argentine Province of Rioja, rises to 20,680 feet, and the grand mountain Tupungato 22,015 feet high.

Between Argentine and Chili, between latitude 23° and 35°, the mountain passes, which are from 10,000 to 14,000 feet high, are blocked with snow from May to August, and they are swept by violent storms.

The height of the passes, all the way from 7° to 37° south latitude, Northern Peru to Southern Argentine, shows the determination of Nature to oppose transit by man, piling up in his pathway these almost insurmountable obstacles. When it is considered that this immense barrier covers a sixth part of the circumference of the globe, its influence upon the development of the continent is apparent. The general condition, so far as civilization is concerned, and the obstacles in the way of mankind are forcibly and most interestingly described by Colonel Church, comparing them with the conditions in North America:

"The contrast between North and South America is remarkable. Nature was in her kindest mood when she created the former—gave it vast and fertile plains; low and readily transitable mountain ranges; extensive systems of navigable lakes and rivers—the latter not too difficult to

bridge; great forests of the most abundant timber; immense mineral wealth, including an abundance of coal and iron; a coast-line offering numerous excellent harbors easily accessible from the interior, and a temperate, inviting climate over almost its whole area. It is a land where man seems to live with Nature on friendly terms, and where the wave of humanity, as it rolls westward, encounters no obstacle which it cannot readily overcome.

"How opposite to all this is South America! It lies mostly within the tropics. Its fertile plains, except those of the Argentine Republic, are difficult of access; it is a formidable task to scale and cross its mountain ranges. Its rivers, with rare exceptions, are of violent flow and full of obstacles to navigation, and its largest ones not within the limit of practical engineering to bridge. Its vast forests are hard to work and frequently impenetrable. Its mineral wealth, immense in nobler metals, includes but little coal and iron. Its coast has but few good harbors, and these are almost all mountain-locked. Its climate, although in many parts delightful, is uninviting over extensive regions. The forces of Nature are so vigorous that man can seldom count upon the unqualified control of them, and, in general, they confer generous reward only upon well-applied and persistent energy."

The above is an introduction to his very important paper read before the Royal Geographical Society, February 25, 1901, entitled "South America: An Outline of Its Physical Geography," a paper of seventy-four printed pages. His conclusions are as follows:

"My analysis shows that, in general, man finds himself confronted by severe conditions in his struggle with Nature in South America. Thus far, however, his efforts to develop and utilize its vast resources have made its commercial history an epic. The thought naturally presents itself: that had North America fallen to the lot of the Latin race in the European occupation of the New World, and South America to the Anglo-Saxon, the former might still have maintained its supremacy; for the more rapid progress of the former may not be due so much to racial superiority as to advantageous geographical surroundings."

Having outlined the physical conditions and shown their importance and influence, let us review very briefly the history of man among these extraordinary physical features of a great continent.

Mountains and streams and soils, and nature in general, are always of interest; but man—his history, his ethnology, anthropology and biography are of still greater interest to us, especially when human life and character have impressed themselves upon the country in which we are immediately interested.

I am tempted strongly to take you on an excursion in the wide field of American ethnology and examine the races and tribes that were found by our first ancestors when they came and began the development of both North and South America, but time compels me to limit myself to an allusion only; for a volume would be required to take up the subject of the savage tribes alone of America—450 principal groups, and 2,000 if we separate them by dialects. And another volume would be needed to treat of the civilized aborigines of the table-lands of Mexico and Peru; of the Toltecs and Aztecs and of Quetzalcoatl and the Incas; the pontifices, who ruled over a vast population covering 40° of latitude of South America, from Northern Argentine to the Antilles. The barbarism of the savage and the civilization of the races of the table-lands have nearly disappeared. You would have no better knowledge of that vast horde of wandering tribes that infested the great plains of the Pampas if I should mention their names. Some few still exist; the census gives less than 20,000 as the total of Indians still existing in Argentine. Once numerous and brave, only about a dozen remain of the Paraguas, the descendants of the Aguas; and of the Tobas and Chinipis, who later occupied their country, a remnant only exists. From the photograph you may judge of their present character.

It is unnecessary to go into the history and the influence of the Incas; they have been described in the histories to be found in every library of the land. But it may not be generally known that, from the first arrival of the Spanish adventurers to the successful end of the great struggle for

liberty in South America, there was always dissatisfaction, unrest and hatred of the conquering race. The seeds were sown in bloodshed, in the persecution by the Inquisition and in false commercial and governing methods of Spain and Portugal, the mother countries. The difference between North and South America in this respect was very great.

The symptoms of resistance against Spanish domination showed themselves in the dawn of the history of South America. Frequently the Indian tribes attempted to throw off the yoke of some more than usually severe and cruel oppressor. In the early days of the eighteenth century the revolution of Tupac-Amaré was really a war of races rather than a political revolution, as it had for its principal purpose the extermination of the Spanish. In Venezuela, in 1711, this same hatred showed itself in the proclamation of a mulatto as King of the Mestizos. Half a century later the seed sown by Antequera bore fruit in New Granada, when an army of 20,000 men was raised and commanded by Berber.

It is a significant and curious fact in the history of South America that, during the entire eighteenth century, the same causes were producing the same effects among people far separated from each other and of a character entirely distinct, scattered from the banks of the Paraguay River to the Colombian Mountains.

Those effects may have been the precursors of that great revolutionary movement that created our great republic and drove the Bourbons from the throne of France, and, later, shook to the center the monarchical fabric of Spain herself.

We may therefore say that the struggle and the preparation of the ground for civil and religious liberty began earlier in South America than in North America. In the British Colonies there was no strong sentiment against foreign rule until the imposition of the taxes required to furnish George III with revenue to pay off his debt of £148,000,000 sterling. Even Washington, in July, 1775, when he took command of the Continental Army, declared that the idea of independence was repugnant to him. Only

later, and soon, when the war was suddenly upon the Colonies, did events hasten and make inevitable the separation from the mother country.

It would be a subject of great interest to enter upon—the three great leaders and heroes of American revolutions—

WASHINGTON, BOLIVAR, SAN MARTIN—

a triumvirate of liberators.

Of the former two you already know much, possibly of the latter; but you may not know that it was by his patriotism and generalship that the whole of Southern South America was freed from the yoke of Spain—Argentina, Chili, Peru and Bolivia. His biography is a romance of most absorbing interest.

Born 1778 in Argentine, in Japeyú; his early education in Buenos Ayres, completed in Spain; served with distinction and great bravery in the wars of Spain. Early he was imbued with the doctrine of liberty for his native country; spent a year in Great Britain, in 1811, forming associations and a secret league devoted to the liberation of Argentine. Landed in Buenos Ayres in 1812; soon in command of a regiment of grenadiers; selected soldier by soldier, officer by officer; imposed the most rigid discipline, forming so a rudimental school for a generation of heroes that followed him, and produced nineteen generals and nearly all the great men of the struggle for independence; placed in command of the army to reorganize it; marched to Mendoza, the nearest point to the Andes; and, imbued with the idea that no liberty would be secure for his country until the Spanish armies were beaten and expelled from Chili, Peru and Bolivia and the whole of South America, he formed his plans for an invasion of Chili. He was the very incarnation of determined patriotism; nothing, not even revolutions and discords behind him in his own country, could deter him from his great work. At this moment Napoleon fell, and Spain prepared an expedition of 15,000 men destined for the Rio de la Plata. In Chili and Peru the Royalists were victorious; but in Argentine, on the 9th of July, 1816, at Tucuman, the declaration of independence was pro-

claimed, which, like our own, is sacred in the heart of every Argentine.

In the midst of these great and momentous events, San Martin recruited and drilled and clothed and provisioned his little army destined to conquer a continent, to scale high mountain passes and pour down upon an enemy largely outnumbering his own. His plans were known only to himself, and when asked by those high in authority what they were, he refused to tell and said *no* one should know them; and should his pillow get an idea of his plans he would cast it into the deep. He ostensibly made roads over certain passes and, when all was ready, led his army over another and very different pass and came down upon his foe and defeated him in Chacabuco; and again, on the plains of Maipú, routing the enemy completely and assuring the independence of Chili. Then, though anarchy was reigning in Argentine and his Government was calling upon him to return, his fixed and irresistible purpose of dealing the final blow to Spanish authority in Peru pushed him forward. With a fleet hastily gotten together and commanded by Lord Cochrane, and with English and U. S. officers in command of the ships, he sailed from Valparaiso with his troops up the coast in December, 1818. He had only 4,430 men, Agentines and Chileans. The Viceroy of Peru had 23,000 soldiers awaiting this little army. On July 28, 1821, as a result of his campaign, the independence of Peru was proclaimed in Lima and San Martin made dictator. In the meantime General Bolivar, after liberating Venezuela and Colombia, reached Quito, and his forces united with an Argentine division, routed the Spanish army in the battle of Pichincha; and then he hastened on to Guayaquil, anxious to finish by himself the Peruvian campaign. Here let me quote a paragraph from the history of Argentine by the Hon. Martin Garcia Mérou, the Argentine Minister at Washington:

"There he went to find San Martin, whose purity of character and noble unselfishness formed a marked contrast with the impetuous ambitions of his glorious rival. The two liberators had a conference July 26, 1822, the details of

which were kept secret; but it is a well-known fact that San Martin comprehended that, in order to save South American independence and avoid the scandal to the world of a break with Bolivar, caused by the latter's thirst for glory, it would be best for him to depart from a scene where his great presence had no place."

The story of self-abnegation and the rest of his life is told in a word. He resigned the dictatorship of Peru; passed to Chili, to Mendoza, to Buenos Ayres, to Europe, where he resided four years in Brussels on a very modest pension. Once more, in 1829, he returned to the La Plata, landing at Montevideo, but learning that anarchy prevailed in his own country and deaf to the entreaties of his friends to come to their help, he took a steamer back to Europe, saying: "No; General San Martin will never spill the blood of his fellow citizens; he will draw the sword only against the enemies of America." And, without even seeing Buenos Ayres, he sailed for the last time to his voluntary exile, dying suddenly August 19, 1850. He was free from those theatrical qualities which appeal to the multitude. In his great character predominated those moral qualities which entitle San Martin to a prominent place in South American history. Inflexible in the discharge of duty, a rigid disciplinarian, everything was subordinated to the high mission to which he had devoted himself, and he never sacrificed his cause to ambitious or personal vainglory. *He was the incarnation of an idea.* His modesty, his pure and elevated character, the simplicity of his life and the nobility of his principles give him rightfully a position by the side of the great heroes of history.

In the vicissitudes of the epoch under consideration, when European wars and the disasters of nations reflected themselves directly and indirectly upon the people of the River Plata and led slowly to the formation of the Republics of Uruguay, Argentine and Paraguay, many notable and great men, as well as despots and bloody tyrants and political demagogues, appeared upon the scene and the pages of history. No name more illustrious, contemporaneous with San Martin, is seen in the records of that time

more brilliant and more important in results than that of General Belgrano. His generalship, diplomacy, statesmanship and exalted patriotism give him a most distinguished position in the annals of independence As General Mitre has well said in the opening sentence of his history of Belgrano: "This book is at the same time the biography of a man and the history of an epoch." His statue is before us as we stand in the archway of the National Government Building and look out upon the beautiful Plaza Victoria. General Belgrano was really the author of the national flag. The white and the blue are the colors of the uniform of the Patricios, the regiment of native Americans at the time of the overthrow of the Spanish Viceroy, on the 25th of May, 1810.

[*To be continued.*]

Notes and Comments.

ALUMINIUM ALLOYS.

Among the aluminium alloys recently placed on the market, two have especially occupied the attention of metallurgists in a prominent way—namely, "magnalium" and "meteorit"—two German inventions. A report on the properties of these alloys has recently been published by a German contemporary, from which we take the liberty to quote the following description:

About ten years ago Dr. Ludwig Mach experimented with alloys for the production of metal mirrors. It was considered indispensable that the composition aimed at should be light, hard, tough and susceptible of polish, and that its gloss should not be easily affected by the air. An equal mixture of magnesium and aluminium proved a very suitable alloy. Following up this discovery Dr. Mach systematically tried all possible proportions of magnesium and aluminium according to their properties and technical adaptability, giving the most approved one the name of magnalium, on the production of which he has obtained patent rights from the Imperial Patent Office at Berlin. Before this, various experiments had been made, with a view to the discovery of suitable alloys, but as at that time neither of the two metals could be obtained technically pure, the alloys did not possess the valuable properties which distinguish the new magnalium.

Aluminium, as well as magnesium, is most difficult to work, inasmuch as the former chokes up the file and is liable to break, while the latter is so tough that neither a file nor the turner's chisel can make any impression. Magnalium, on the other hand, is more suitable than either of its component parts. Alloys containing up to 30 per cent. of magnesium, furnish a metal the hardness of which lies about half way between yellow and red brass, and

which may be easily worked with any tool; even the weakest screw-threads can be cut with proper keenness. The chips are like those of yellow brass, the faces of the pieces are smooth and bright, and choking never takes place even with the finest files. Magnalium, moreover, is chemically less assailable than either of its components. Aluminium by itself has a very indifferent exterior, while magnesium by itself is greatly affected by the air, and oxidation will gradually extend far into the interior. Magnalium is silvery white, remains unaffected by exposure to the air, nor can ammonia or acetic or sulphuric acid harm it in any way. It surpasses aluminium in gloss, tractability, firmness and lightness.

The combinations of aluminium with copper or with zinc can easily be made, but as these two metals are a great deal heavier than aluminium, all the advantages due to the light weight of the latter are lost. While aluminium has a specific weight of 2·7, the alloys referred to range betwe n 3 and 3·5. A notable contrast to this is presented by the specific weight of magnalium, which is less than that of pure aluminium—namely, 2 to 2·5—according to composition. Magnalium produced in Sweden shows a specific gravity of only 2·4 to 2·7.

Magnalium is sold in the form of bars, tubes, sheets and wire. For melting purposes, crucibles of graphite or of iron are used, the inside of the latter having been lined with clay and magnesia. Molten magnalium can be poured into the thinnest vessels of a diameter of down to 2 millimeters and of the most intricate forms, and will fill them up thoroughly and faultlessly. It becomes soft at 570°, melts at 600° and becomes fluid at 630° C. On account of its lightness and its silvery white color it is in a high degree suitable for metallic mountings on photographic apparatus, optical instruments and similar articles.

Unfortunately, sea-water is inimical to magnalium, especially when the latter comes in contact with other metals. This defect renders it, of course, impossible to use the new alloy for ships, as desirable as this might be, on account of its lightness and eminent solidity, especially for men of war.

In cases in which, for technical purposes, great solidity is of paramount importance, as, for instance, in regard to large castings, an alloy of from 3 to 5 per cent. of magnesium is most suitable. An addition of 10 per cent. of magnesium would render magnalium brittle, while 30 per cent. of magnesium would reduce the solidity of the alloy still more. With only 2·4 per cent. of magnesium added, magnalium can be forged at a temperature of 400° C., and will then act in a similar way to copper at red heat. If containing less than 5 per cent. of magnesium, it may be forged in the cold state, and if perchance the hammering has rendered it too hard, it can be made malleable again by heating to a temperature of 500° C. and chilling it thereupon in cold water.

The price of magnalium is about the same as that of copper, and depends mainly upon the price of magnesium. Whereas, aluminium may be had (in Germany) for 2 marks (48 cents) a kilogram, the price of magnesium is kept up steadily at 20 marks a kilogram. Were it not for the high value of the latter metal, the price of magnalium would be considerably lower than that of copper. It is, however, to be expected that the growing demand will lead to an increased production of magnesium, with the result that also this metal will come down much like aluminium, which, as is well known, has expe-

rienced an extraordinary reduction within the last few years. The cheapening of magnesium, however, will be the forerunner of more moderate prices for magnalium.

It remains to be seen whether magnalium will fulfil all the promises given above. Our report states in a general way that aluminium-magnesium alloys also show when worked the great defects of mechanical mixture, as hard places frequently occur in the work. If the tool comes in contact with such hard places it frequently breaks, or the material breaks away, whereby the work done may be considered as practically lost.

ODD USES FOR RAWHIDE.

It was the great packing and killing houses of Chicago which helped to bring about the present uses of rawhide, says the New York *Sun*.

Rawhide is a form of leather in which the curing process stops far short of destroying the life of the material. The result of this treatment is a product remarkable for toughness, durability, tensile strength and pliancy. It is used for belting, rope, hydraulic packing, laces of various kinds, pinion-wheels, washers, harness, mauls and mallets, flynets, trunks, saddles and artificial limbs.

Rawhide rope is handsome and astonishingly strong, besides having great power of resistance when exposed to the action of the weather. At a little distance it looks like very white and clean new hempen rope. It is delightfully supple, and once tied it holds for a lifetime. The cost of such rope puts it beyond the reach of most consumers, yet for some purposes it is the cheapest material that can be used.

It costs from 10 or 12 cents to more than $2.75 a foot, according to diameter and quality. The cheapest is about ¼ of an inch in diameter; the most expensive, save that made to order in special sizes, is 2¼ inches in diameter. It is largely used for the transmission of power, especially where the line of transmission is long and indirect. Only a close examination brings to light the points where strands are joined, and splicings are so made that they show no change in the diameter of the rope.

One of the most curious applications of rawhide is to the manufacture of pinion-wheels for the transmission of power. Such wheels are usually made of iron or steel, but the rawhide can be made sufficiently rigid, hard and tough to serve all the purposes of metal in such articles. The rawhide pinions are almost noiseless, and they require little lubrication. A somewhat similar use is in the gear of friction wheels.

Mallets and mauls of rawhide are used for a variety of purposes in manufacturing. The former are entirely of hide save the handle; the latter have a wooden or metallic base with a rawhide face. Hammers with rawhide faces are also made.

The old-fashioned rawhide whips, the "cowhide" of many a social and political row, are made in several forms, as are blacksnake whips of the same material, rawhide lashes, and miners' whips. Rawhide lariats are also manufactured, though there was a time when every plainsman made his own. They cost from 15 to 20 cents a foot, according to diameter and form of pleat. They are rarely seen east of the Mississippi save in the factories.

Book Notices.

Worm and Spiral Gearing. By Frederick A. Halsey, Associate Editor *Am. Machinist.* 12 mo. pp. 85 New York: D. Van Nostrand Company. 1902. (Price, 50 cents.)

This volume forms one of the well-known "Van Nostrand Science Series" and is substantially a republication from the *American Machinist.* The author refers to the prevalent opinion among designers of machinery that worm-gearing is necessarily short-lived and of low efficiency, and to the circumstance that the methods of laying out spiral gearing are not generally understood, as his justification for publishing his work in book-form.

The work is divided into two parts: (1) devoted to worm-gearing, and (2) to spiral gearing. In Part I, the theory of worm-efficiency and its experimental corroboration are treated of, with examples from practice.

In Part II, spiral gears are compared with spur gears, and both analytical and graphical methods of laying out are given. The work is illustrated by a number of plates. W.

Electro-Chemical Analysis. By Edgar F. Smith. Professor of Chemistry, University of Pennsylvania. Third edition, revised and enlarged, with 39 illustrations. 8vo, pp. 203. P. Blakiston's Son & Co, Philadelphia. 1902. (Price, $1.50.)

Professor Smith's numerous contributions to the application of the electrochemical method to the quantitative determination of metals and analytical operations are widely known His present work, though entitled a third edition of his "Electro-Chemical Analysis," is practically a new book, having been substantially re-written. An interesting and useful feature is the introduction of a description of the proper equipment of an electro-chemical laboratory. In the special portion of the book, the methods of separation have been thoroughly revised. Quite a number of new illustrations have been introduced. W.

Die Gewinnung des Aluminiums und dessen Bedeutung für Handel und Industrie, von Adolph Minet. Ins Deutsche übertragen von Dr. Emil Abel (Mit 57 Figuren und 15 Tabellen im text). Large 8vo, pp. vii + 129. Halle a S. Verlag von Wilhelm Knapp. 1902. (Price, 7 marks.)

Die Darstellung des Chroms und seiner Verbindungen mit Hilfe des elektrischen Stromes. Von Dr. Max Le Blanc. Large 8vo, pp. 108. Halle a. S. Verlag von Wilhelm Knapp. 1902. (Price, 6 marks.)

The publications relating to electro-chemistry and electro-metallurgy now appearing from the press of above-named publishing house, promise to make an extremely valuable set of contributions to the literature of these important and rapidly growing branches of the electrical arts.

The volumes above entitled are respectively No. II and No. III of a series of special monographs on applied electrochemistry—one dealing with the aluminium industry and the other with chrome and its compounds. W.

The Elements of Electrical Engineering. A first year's course for students. By Tyson Sewell, A. I. E. E., etc. 8vo, pp. x + 332. New York: D. Van Nostrand Company. London: Crosby Lockwood & Son. 1902. (Price, $3.00.)

This work is based upon courses of lectures given by the author to classes of students intending to qualify as electrical engineers. The author has avoided, as far as possible, the mathematical treatment of his subject, which will doubtless commend it to those who are not sufficiently conversant with mathematics to utilize it.

A useful feature of the book is the introduction, with each topic treated, of problems, in the form of questions and answers, which cannot fail to prove very serviceable to the student. The work answers its intended purpose very satisfactorily. W.

Einführung in die Elektrochemie. Nach der elektrolytischen Dissociationstheorie bearbeitet von Peter Gerdes. Mit 48 in den Text gedruckten Abbildungen. 8vo, pp. viii + 223. Halle a. S. Druck und Verlag von Wilhelm Knapp. 1902. (Price, 4 marks.)

This work, as its name indicates, is an introduction to electrochemistry, and is intended to serve as a guide in the preliminary study of the fundamentals of the science. The various chapters are devoted to fundamental conceptions, osmosis and osmotic pressure, electrolysis, polarization, acids, bases, salts, etc., electrical-current generation, decompositions by the electrical current, electrolytic laws, tables, etc. W.

A Text Book of Quantitative Chemical Analysis. By Frank Julian. 600 pages, octavo, illustrated. First edition. St. Paul, Minn. The Ramsey Publishing Company, 1902. (Price, $6.00.)

This work treats of the subject in four parts. I. An introductory chapter dealing with tests, methods and general principles of chemical analysis; II, of reagents; III, of special methods and technical analysis; IV, notes on the methods of analysis, and an Appendix. W.

The Art of Illumination. By Louis Bell, Ph.D. 8vo, pp. 339, 127 illustrations. New York: McGraw Publishing Company, 1902. (Price, $2.50.)

This work deals directly with the scientific and artistic use of modern illuminants. The first three chapters are devoted to a discussion of the physical and physiological principles which form the basis of the art of artificial lighting. Then in succession are taken up the properties of practical illuminants and their bearing upon the development of modern lighting. The chapters upon electric incandescent lamps and arc lamps are especially rich in practical information regarding their economical and artistic use. The following chapter (VIII) on shades and reflectors contains a mass of data on this neglected topic which would require a long search to duplicate. Then the lighting of the house, of large buildings and of streets, is treated in successive chapters, and concrete cases illustrative of the principles laid down are worked out in detail. A separate short chapter is devoted to the basic principles of decorative illumination for special purposes, and then the line

of progress in the effective and economical use of the materials at hand is marked plainly out. The volume closes with a clear setting forth of the methods and apparatus employed in modern photometry. W.

A Graphic Method for Solving Certain Questions in Arithmetic or Algebra. By George L. Vose. Second edition. 12mo, pp. 62. New York: D. Van Nostrand Company, 1902. (Price, 50 cents.)

This volume is devoted to the extension of the applications of the graphical method to the solution of many problems in arithmetic and algebra, which may be new to many who are familiar with the system in its general applications. W.

Metallurgical Laboratory Notes. By Henry M. Howe, Professor of Metallurgy in Columbia University, New York. Boston: Boston Testing Laboratories, 1902. 8vo, pp. xiv+140. (Price, $2.50.)

The laboratory notes on metallurgy embraced in the work above named will be found extremely serviceable by students of this branch of applied science. The progress made in this field of late years has been most notable, and the author of these notes has contributed substantially to its development. The experiments described embraces (1) squad experiments and others for a short course in metallurgy; (2) pyrometry and calorimetry; (3) melting points of silicates, etc.; (4) properties of refractory materials; (5) iron and steel; (6) non-ferrous metals; (7) appendices, notices, etc. W.

Franklin Institute.

[*Proceedings of the Annual Meeting held Wednesday, February 18, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 18, 1903.

President JOHN BIRKINBINE in the chair.

Present, 37 members and visitors.

Additions to membership since last report, 17.

Two donations of $1,000 and $5,000, respectively, were reported from the Board of Managers, the donors, in each case, desiring their names to be withheld from publicity.

The action of the Managers in accepting these gifts with the thanks of the Institute was approved.

Mr. G. Everett Hill, of New York, presented a paper on "The Bacterial Disposal of Sewage." The paper was illustrated by numerous lantern-slides, and was listened to with great interest. On the conclusion of the paper considerable discussion followed, many inquiries from members being made for information on points respecting the construction of plants, etc.

The paper will appear in the *Journal.*

Adjourned.

H. L. HEYL,
Secretary pro tem.

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THE FRANKLIN INSTITUTE.

A lecture delivered before the Franklin Institute and the Central Branch of the Young Men's Christian Association, Friday, November 21, 1902.

Two Years in Argentine as the Consulting Engineer of National Public Works.*

BY ELMER L. CORTHELL, Sc.D.

(*Concluded from p. 235.*)

Coming to later times, new and illustrious names appear of men who were true patriots, who would not stoop to fraud or unbecoming political acts, and who, amidst the errors of their time and the temptations to do evil, came out pure as gold tried in the fire. One of these men is the author of the history of Belgrano—General Mitre, still living—the general who led the forces of Buenos Ayres in the last struggle for a united republic, and who may be called the "Father of his country," for under his wise governorship, his skilful generalship and wisdom as President, Sena-

* The lecture was profusely illustrated with the aid of lantern photographs.

tor and a public man always before the people, the country has been strong, united, prosperous and peaceful.

The sincerity of his motives, the purity of his life, public and private; his self-abnegation, his rigid honesty, his lofty ideas of public office, administering it always as a public trust; his modest and simple life—all explains why the entire nation recently honored his eightieth birthday, and why the statesmen of the republic sit at his feet to learn and to follow his wise counsels.

For want of time, I have refrained from developing the political history of the republic, or giving its earlier history—the discovery of the River Plate by De Solis, in 1515, giving the name of his second officer, Martin Garcia, to the now well-known island at the head of the estuary, or the discovery, in 1526, of the Paraná River by Sebastian Cabot and all the subsequent and checkered history of the Spanish-Portuguese rule in the River Plata countries. That they have passed through many trying periods, when the patriotism of the leaders has been severely tested, goes without saying. The heterogeneous elements, the ambitions of designing men, the lack of integrity in the early days of independence and the opportunities which selfish men had easily in their hands to enrich and raise themselves in political station, gave varied and not always envious political changes to decades of Argentine history, not necessary to inflict upon you now. Suffice it to say that the country has passed safely through those terrible ordeals. The principles of the 9th of July, 1816, in the Proclamation of Independence, and those laid down May 25, 1853, in the Constitution of the United Provinces, form the basis of the republic—fourteen provinces (states) and ten gobernaciones (territories)—principles which all hold sacred and which are almost exactly similar to our own.

The world, and especially its republics, owe more to Buenos Ayres than is generally known or recognized. The brief but eloquent summary of this period of its history by General Mitre shows how great has been its influence in the development of American national life:

"On the day, when the Chieftain Ramirez was routed

and slain, and that Varrera fled, seeking the sepulchre of his brethren, and that the farmers of Salta rose emasse to obey the order of the dying Gúemes, General San Martin, the 10th of July, 1821, was triumphantly entering Lima, and Bolivar, the conqueror of the north of Ecuador, was going at the head of the armies of Columbia to meet the Argentine liberator in order to seal the independence of the New World, already irrevocably assured by the occupation of Lower Peru, liberated by San Martin.

"Here ends the history of the independence of the Argentine Republic. If she was the precursor in chronological order, she was also the first to give the signal for the great insurrection which emancipated the Spanish-American Colonies from the mother country. It conquered its independence by its own efforts and without foreign help; it fought eleven consecutive years; it expelled its enemies from its territory, taking possession of their fortified places and conquering their squadrons upon the seas; it hurled back triumphantly upon the land the nine royalist invasions which endeavored to subjugate it. Its revolution is the only one which was not overcome, while all the others were, from Chili to Mexico.

"Devoured by anarchy, it struggled with it arm to arm, and at the same time carried its liberating arms to Paraguay, to the Banda-Oriental, to Peru, upper and lower, and its banners arrived victorious at the boundaries of Ecuador in the struggle for the independence of Colombia.

"Simultaneously its internal revolution took form, and upon concluding its second evolution with its own organic elements, the United Provinces of the Rio de la Plata, now in peace and re-organized according to the plan of an embryonic federation, which was to be the law of the Constitution in future, had sketched out its political map, tracing upon it with the sword of independence the inviolable line of its frontiers.

"It only remained for Jujuy, emancipated from Salta, to resume its federal autonomy, and to rise above the horizon the fourteenth star of this new national constellation. The Spanish power conquered, disorder dominated, and its

organic elements reorganized and reconstituted the Argentine Republic, which, even in the midst of anarchy, had contributed so much to secure its own independence and that of other South American nations was about to initiate a new propaganda of principles, which, like its armies, should spread over the entire South America.

"Buenos Ayres was the initiator and the herald of this new Pacific development. This province departed from its primitive plan of organization and gave up the impossible task of uniting the nation politically by means of revolutionary congresses and governments of irresponsible dictators which had shown themselves impotent to constitute and to unify the country. Concentrating itself within its own organic forces, it put in practice the idea of creating the type of a Federal State arranged on a constitutional plan, which should serve as a model to other provinces in the future. This initiation took place under the administration of General Martin Rodriguez.

"General Rodriguez called to his council, in order to realize the work of reorganizing, first, Bernardino Rivadavia and then Manuel José Garcia. These two statesmen carried it to a successful conclusion, with the coöperation of the same men who had fomented and sustained the revolution. Assuring independence and the re-establishing of order, they inaugurated the republican system in Buenos Ayres, breaking forever with colonial traditions; and they laid the foundations of a republican government which responded truly to liberty and progress. A limited legislative power was created, renewable on the base of universal and direct suffrage. The powers of the Executive were determined and its duration, and it was made responsible. Institutions of credit were established, and immigration and popular education were promoted. The income and the estimate of expenses were for the first time organized. The sciences and the arts were cultivated, absolute amnesty proclaimed and public opinion was given participation in the Government, and an extensive reform was carried out in all political and social institutions. In this manner was created the nucleus of Argentine, creating a republican

Federal State and making possible its organization in the future."

I stated in my remarks at Düsseldorf that the country was ambitious and determined to fulfil its destiny among the nations of the earth. I cannot close the political subject of my lecture without confirming this statement by the words found at the close of Mr. Mérou's history of Argentine, which he brings down to 1870.

"The Argentine Republic came out of this campaign (1870, with the dictator and tyrant of Paraguay) strengthened and united. The sentiment of nationality, crystallized by common sacrifices, was from that time forth an indestructible fact and a promise of days of prosperity and greatness, of a country united, free and powerful. We can contemplate the problems of the future with tranquility, consecrating ourselves with all of our intelligence and forces to build up with a broad and generous spirit and a disinterested love for truth and justice (following the traditions received from our forefathers and realizing their noble ideals) one of the greatest, most prosperous and most illustrious nations of the earth."

The United States, at a critical period in the history of South America (1818), presented fearlessly and firmly its pronounced views, and prevented a coalition of European powers for the purpose of compelling the American Colonies of Spain to return and thus re-establish Spanish domination in South and Central America and Mexico. Much to the surprise of the British Minister of Foreign Affairs, our Minister, Mr. Rush, boldly combatted the proposition by the statement that the decided views of his Government were, that the American Colonies of Spain should be completely emancipated from the mother country, and that in its opinion there could be no further outcome of the struggle which Bolivar and San Martin were engaged in on the Andean Plains.

As a concession to the American Minister, Lord Castlereaugh, the British Premier, stated that Buenos Ayres, (Argentine) among all the insurrectionary colonies, had given the best proof of its capacity to exist as an indepen-

dent nation, and its commerce had the greatest importance at the time and the best promise for the future. Our Minister in Paris, Mr. Gallatin, aided by Lafayette, was using his influence for the acknowledgment of the independence of the American Colonies of Spain. Our Government in 1818 was the first power of the world to recognize Argentine as a nation, by granting an "exequatur" to a Consul General appointed by that Government. This same country, having proven by its works its right to exist, now stretches out the hand to its benefactor of nearly a century ago and asks the interchange of products and its coöperation in its efforts to fulfil its high destiny among the nations.

It is pertinent here to remark, that the principle enunciated in 1818 with such quiet but firm determination, viz: That *America* is, and shall be, the undisturbed home of *Americans*, has persisted until the present day, and if attempts have been made at any time to impair the sovereignty of any American nation, there has always been a Grant or a Cleveland to frustrate them. President Roosevelt has recently clearly defined this much misunderstood principle, or so-called "Monroe Doctrine," when he said, "the nations now existing on the Western Continent must be left to work out their destinies among themselves," and "America, North and South, is no longer to be regarded as the colonizing ground of any European power." Thus it has happened that, while the Dark Continent has been partitioned among these powers, no hand as yet has been laid upon any part of America.

A correct interpretation of this "doctrine" is absolutely essential to a complete understanding and cordial accord between us and the other countries of North and South America.

An incorrect knowledge of it, particularly among the South American people, has engendered a popular antagonism to it as being unworthy of themselves to accept, without their consent, the suzerainty, or tutelage, of the United States, especially as their social and commercial affiliations are with European countries, from whom our Government has politically protected these republics for nearly a century.

Let us now take a bird's-eye view of the present Argentine, a country one-third the size of the United States, a climate salubrious and comfortable, of immense plains formed by Nature, as I have already shown, for the use of man—plains where the railroads find no natural obstacles worth mentioning in the way of their good alignment and construction; where we have, I think, the longest railroad tangent in the world, 186 miles, between Junin and La Cautiva, on the Pacific Railroad—plains covered with the cattle of the great estancias (ranches), thousands of them, of the best breeds in one estancia, and sheep by the millions, and great fields of wheat, corn and linseed, the principal agricultural products of the country. An "estancia" might be called a ranch on the great plains of our Western States. The size varies from about 3,000 acres to 700,000 acres; probably 25,000 acres might be considered an average size.

As might be expected, the business of cattle-raising requires expert men similar to our cowboys; they are called "gauchos." They are fearless riders and masters of ther trade. The horses they ride are generally rather undersized, but wiry and of great endurance. They are much like the best class of Mexican horses.

As the cattle roam over great ranges which are unfenced, it is necessary to brand them, as we also do on our great plains.

The homes on the estancias of the gauchos are not elegant, to say the least; but in the comparatively mild climate of Argentine they do not need as much protection from the weather as in many of our cattle districts of the Far West. They are a contented people, and while they do not have the facilities for entertainment which a city population has, they nevertheless have their fun on feast days, and whenever their arduous and roaming life will permit.

As might be expected of a country stretching through so many degrees of latitude and rising along the circles of longitude from the level of the sea to the highest Andes, there is a great variety of climate, and generally an abundant rainfall. Buenos Ayres is on the same parallel south of the equator as Wilmington, North Carolina, is north of it.

Snow is almost unknown, and scarcely ever is ice or frost seen. The climate in the summer is tempered by the great body of water of the River Plate.

The rainfall of Buenos Ayres averages 35½ inches per annum, about equal to that of the Northern States of the United States. At Asunción, Paraguay, it is 53 inches, about equal to that of New Orleans. The temperature is remarkably uniform. The mean temperature in June and July, 1899, the coldest months, was 54° F., and in January and February, the hottest, 76°; the annual mean being 62°. In twenty years the mean was 63°; summer, 77°; autumn, 65°; winter, 54°, and spring, 63°; mean of January, the warmest month, 79°; of July, the coldest, 52°. The extreme or extraordinary limits were 107° and very rare 104°, frequently 95°, and in winter 23°, which occurred but three or four times. In February, 1900, the heat rose to 103°, but the period of intense heat was only eight days. Such conditions are extremely rare.

A recent writer treating of tropical countries has truly remarked that "civilization is the product of geographical environment.

"If we divide geographical environment into its unchangeable and its changeable factors, we find the former to consist of climate, the configuration of the land, and the nature of the soil; and the latter of the surface conditions, which may be changed, for example, afforestation, deforestation, or agriculture; the situation of a country, the effects of which may be modified by the introduction of railways, steamships and telegraph lines; the unhealthfulness of a country, which may be counteracted to some extent by hygienic science.

"If we draw across a map of the world the northern and southern isotherm of 68° F., that is to say, a line passing through these places in the Northern and Southern Hemispheres which have a mean annual temperature of 68° F., we cut off a belt of the earth's surface 3,600 miles across, lying roughly between 30° north latitude and 30° south latitude. This belt is called, for the sake of convenience, the heat belt. In this heat belt lie Mexico, the Central Ameri-

can Republics, the West Indies, the greater part of South America, practically the whole of Africa, Arabia, India, Burmah, Indo-China, the Malay Peninsula, the Malay Archipelago, Polynesia and Philippine Islands. Outside the heat belt lie the United States, the United Kingdom, Canada, the greater part of Australia, Japan, the greater part of China, and the continent of Europe."

He might have included the southern half of Chili and the southern two-thirds of Argentine, as they are below the thirtieth parallel of south latitude, and the isotherm of 68° F. is 5° north of that of Buenos Ayres, which, as a mean of twenty years' observations, is 63°.

"The extreme significance of this grouping becomes apparent when we reflect that, apart from the work done by Europeans and Americans in the tropics, the civilization of the heat belt has remained stationary for a thousand years, and that the advancement of humanity during that period has been carried on entirely by the inhabitants of these countries which lie outside the heat belt.

"Bearing in mind the elements which go to make up our own civilization—Western civilization, so called—it is most important to realize that during the past 500 years, to go no further, the people of the heat belt have added nothing whatever to what we understand by human advancement. The natives of the tropics and subtropics have not during that time made a single contribution of the first importance to art, literature, science, manufactures or inventions; they have not produced an engineer, nor a chemist, nor a biologist, nor an historian, nor a painter, nor musician of the first rank; and even if we include half-castes and such natives as have enjoyed European education, the list of eminent men produced by the heat belt can be counted on the fingers of one hand.

This reasonable statement places Argentine among countries of a temperate climate, and shows why it and Chili are strong and progressive.

The *agricultural*, *industrial* and *commercial* features are those of greatest interest, and yet, to give you an adequate idea of them, I must give you figures, and they are not

always interesting; but an intelligent audience prefers them to any "glittering generalities," desirous of knowing what Argentine really is and has.

The population of the whole country is now about 5,000,-000; its present rate of growth per decade is about 40 per cent., the United States is 20 per cent., Germany 16 per cent.

The Province, or State, of Buenos Ayres, is as large as Illinois, Indiana, Maryland, Connecticut and Massachusetts combined, or two and one-half times as large as New York State—120,000 square miles, and mostly plains, with 750 miles of coast line. It has 1,200,000 inhabitants, 10,000,000 head of cattle, 80,000,000 sheep and 2,000,000 horses. In 1901 it raised 862,000 tons of wheat and 1,360,271 tons of corn—a respectable showing; and the value of agricultural and pastoral products was $740,000,000. The wheat area of the republic, mostly in four provinces—Buenos Ayres, Santa Fé, Cordova and Entre Rios—is about 8,500,000 acres. Eighty millions to 100,000,000 bushels of wheat are exported. The total area under cultivation in the republic in 1901 was 17,500,000 acres. The increase over 1891 was 136 per cent. The crops were: Wheat, 1,964,000 tons; linseed, 490,000 tons; corn, 2,134,000 tons. The total of arable land is 253,000,000 acres, of which 240,000,000 do *not* need irrigation.

In the whole republic there are over 30,000,000 head of cattle—the annual increase is 25 per cent.; 5,600,000 horses and 120,000,000 sheep. In the United States there are 62,000,000—the annual increase is 33 per cent.; 2,634,105 carcasses were sent to Europe as one item of export. There are 300,000 goats in the country.

One of the important industries of the country is the "saladeros," which from its name signifies salted or jerked beef and extract of beef, etc. Nearly $40,000,000 are invested in them. Brazil is the principal market. Over 1,000,000 head of cattle were killed for the saladeros in 1900. The meat-freezing factories exported 100,000 tons of meat in 1901. An important factor in the Argentine meat trade, and it may be said in the meat trade of the world, is the successful result of continued efforts to send chilled beef to Great Britain. The River Plate Fresh Meat Company started this

trade in 1901, exporting in that year 29,919 quarters of beef; and from January 1 to May 31, 1902, five months, it exported 38,148 quarters.

Since that date the imports into Great Britain have rapidly increased, and recent despatches from London relate how this new factor in the London meat market is alarming the Beef Trust of the United States, and the Australian shippers. Argentine is placing its chilled meat in London at a considerably lower price, and is competing successfully with meat from the United States.

As might be expected, the wool industry is very important, about 500,000 bales shipped to Europe being the export product—in the year 1901-1902, 31,000 to the United States and 28,000 to Great Britain.

Argentine is a protectionist country, and its resources for conducting the Government are largely raised from the customs dues. In 1899 the imports free of duty amounted to $14,769,933 (gold), and those subject to duty $102,080,738 (gold). The exports were $184,917,531 (gold).

The United States imports $300,000,000 per annum of sugar, hides, linseed, jute, hemp, wood and fruit, and $36,000,000 of wool and woolen articles. All of these are produced by Argentine, yet only $6,000,000 of the $336,000,000 come from Argentine, or 2 per cent.

The United States exports, including cereals, meat and live stock, about $920,000,000, and only about $10,000,000 of this go to Argentine, or about 1 per cent.; while Argentine's purchases of the same articles in England were $39,000,000, and $60,000,000 from other countries.

Reciprocal trade would open the United States to Argentine wool and treble the production in a few years. There should be direct lines to that country from the United States, and the time should be reduced from about twenty-seven days to fifteen or eighteen days. We should ship to Argentine our manufactures, our coal, pine wood, petroleum, etc., and we should receive from Argentine its wool, hides, grease, dried fruits, hard wood for tanning and dyeing, etc. Now, for want of return freights, steamers load at United States ports for Buenos Ayres and return via Liverpool to New York, frequently via South Africa.

In reference to wool, I have already stated that in the entire United States there are only about 62,000,000 sheep, while there are 120,000,000 in Argentine. In the province of Buenos Ayres alone there are over 80,000,000 sheep. It is a well-known fact that the ranges in the Far West of the United States, which are absolutely necessary for sheep-raising, are rapidly being reduced by the extension of our population westward, and the cutting up of great areas into smaller farms. Not only do the smaller farmers as they go West wage constant war with the sheep-herders, but the cattle-raisers do the same; so that the time is sure to come very soon when we will need the wool of Argentine. What this country should do with a great agricultural country like Argentine, capable of immense productions, is to receive its raw materials and ship to it our manufactured goods.

It is proper, in closing this part of the subject, to quote a short paragraph which appears in the "Argentine Year Book," recently published, from the pen of Mr. Ronaldo Tidblom, Chief of the National Department of Agriculture and Live-Stock Industry. In closing up a long and very important article in that "Year Book" on the agriculture of Argentine, he makes the following statement:

"Nature has undoubtedly endowed Argentine with advantages for agricultural and pastoral farming not to be found in any other country of the world, and it is not too bold a forecast to say that if the country continues to improve her natural gifts in the same degree in which they have been cared for and improved up to the present time, the day will come when the Argentine farmers will have absolute control of the world's food markets."

The money of the country is on a paper basis, and the minimum value of a dollar was fixed in 1899 at 44 cents gold, or 127 per cent. premium. The market value of a gold dollar expressed in paper money varies now between $2.27 and $2.34, and the gold dollar of the United States is at a 5 per cent. premium over that of Argentine.

Railways have had an extensive development. In 1867 there were 355 miles; in 1880 there were 1,563; in 1890, 5,862; in 1900, 10,601, of which 1,243 belong to the Govern-

ment and 9,358 to foreign companies. In length of line Argentine stands ninth in the list of countries, but as compared with the United States the mileage is about 5 per cent. The paid-up capital is $550,000,000 (gold). The total receipts in 1900 were $40,000,000 (gold). Comparing the railroads of Argentine with those of the rest of the world, we find that in Argentine the length of line per 1,000 inhabitants is 3·46 kilometers, while it is 4·86 in the United States, 0·93 in Germany, and 1·70 in France.

The great Southern, the Western, and some other lines are still making extensions, and the Southern has crossed the Neuquen River and is looking for a pass to cross the Andes.

There are three gages—5 feet, which is really the standard; 4 feet 8½ inches, and a narrow gage, usually about 3 feet 3 inches (1 meter).

The total length of telegraph lines is 28,000 miles, of which 12,000 belong to the Government. Compared with the United States, the Western Union alone has 192,705 miles of poles and cable.

One of the most interesting railroad lines now in construction is the Transandine, which, upon leaving Mendoza, follows the Mendoza River to its source and climbs to the summit of the Pass of the Andes, 3,900 meters above the sea level (13,000 feet). The Abt system of adhesion up to 2½ per cent. and then Rack to 6 per cent. is employed.

Some very interesting views can be had of the approach from the Argentine side. Lofty mountains, rugged slopes, rushing rivers and the Puente del Inca (the Incas' bridge), a natural bridge, formed evidently by the river breaking through a great deposit of cemented material, caused by an avalanche. The railroad is not completed, and some of the most difficult work is yet to be done.

Speaking generally of the railroads, they are well constructed, though good ballast on the great plains is lacking. The cars are like American cars, but the first-class day coaches are much more luxurious than ours. All the long-distance trains have comfortable sleepers; a buffet and dining-car goes with all through trains.

In regard to the industries of the country, while the main products are agricultural and the exports as well, important industries are slowly developing. While sugar is an agricultural product the fifty-one sugar-mills may be classed among the industries. In 1870 Argentine imported 22,000 tons, but in 1901 exported 58,000 tons. There are $52,000,000 invested.

There are over sixty breweries in the country. The annual product is about 440,000 gallons.

There are 182 distilleries; the alcohol is made principally from corn. The annual product is about 3,000,000 gallons.

Milling is a very important industry. The first flour-mill was built in 1580 in the city of Cordova; the first steam flour-mill was built in Buenos Ayres in 1845. In 1895, by the census of that year, there were 659 mills—234 worked by steam and 303 by water; the total amount of flour made was 383,147 tons. The country now exports about 80,000 tons, all in bags and mostly to Brazil, valued at about $3,000,000 (gold). At present the Brazilian market is giving a preference to United States flour because it arrives in barrels, which must lead to the same method in Argentine, although the wood suitable for barrel staves is very limited.

The wine industry is one of the most important. The soil suitable for grapes covers an immense area, extending from the Northern to the Southern Provinces along the slopes of the mountains. Mendoza and San Juan, west of Buenos Ayres, are, however, the best adapted to vine-growing. In 1900 there were 89,000 acres in vines, valued at about $10,000,000 (gold). The transportation of the wine by rail in 1901, in Mendoza alone, amounted to 160,000 tons, and the stock of wine in the wine establishments (bodegas) was 33,000,000 litres (871,000 gallons).

The dairy industry a few years ago had practically no existence, and nothing at all was done with the milk of the millions of cows in the country. Now, large dairies are springing up in all the pastoral parts of the country, and at present the neatest and most tempting places to enter in the city of Buenos Ayres are the white-painted, scrupulously clean places for drinking milk, scattered all over the city,

the milk being sent in from the great "estancias." These dairies are being built in the most approved style, and they prepare pasteurized, maternized, sterilized and all other kinds of milk preparations. The exports of butter alone in 1901 were 3,322,391 pounds; in 1895 it was only 880,000 pounds.

Iron and steel industries are important, although there is practically no ore or coal in the country. In 1895 there were 154 iron foundries and 166 repair-shops, with a capital of $15,000,000. Every class of machinery is now manufactured, even to small engines and boilers.

Matches: The tax alone in 1899 amounted to $2,000,000.

Tobacco: The excise tax on which and its products in 1901 amounted to $4,200,000 (gold).

Four million dollars (gold) are invested in textile manufactures, employing 6,200 persons; canvas factories $1,000,-000 (gold), employing 2,000 persons and making 5,000,000 yards; and $10,000,000 in hat factories, employing 700 hands.

As to mining, there are valuable copper mines containing gold and silver, also rich veins of gold and silver, with recent discoveries of iron-ore; but these various products have not been developed to any great extent, due to remoteness from the railroads and the roughness of the country, making the exportation very costly. The total value exported in 1900 was $262,222 (gold); these minerals include gold, borax, copper, marble, silver-ore, lead-ore, etc.

After this cursory and possibly uninteresting statement of statistics, it is a relief to turn to the beautiful and a really great city of the world, Buenos Ayres, and give you a brief outline of its most important characteristics. First, a little history and more dry figures to give an adequate idea of its size and general features:

Its early history is full of trouble. Founded in 1535, destroyed and rebuilt; and then from 1650, when there were 400 houses, it grew slowly under the old Spanish regime, and, later, under dictators and bad rulers, it slowly advanced in spite of an unstable Government. In 1852, when the noted Rosas was turned out, it had 76,000 inhabitants. Chicago was just then passing through the hard trials of a

little Western town and had not more than 20,000 people. In 1864 Buenos Ayres had 140,000 inhabitants and Chicago about the same; in 1869, 178,000. But Chicago had already started on its phenomenal growth and reached over 300,000. In 1887 Buenos Ayres had 409,000 and Chicago 1,000,000.

In October, 1902, Buenos Ayres had 864,513, and it is growing at the rate of about 40 per cent. per decade. It is destined to reach the million mark by the year 1906. It is now the largest city in the world, south of Philadelphia, if we except Chinese cities.

Comparing its present rate of growth per decade with some other cities, we find the following: Greater London, 20 per cent.; New York, 37 per cent.; Chicago, 54 per cent.; Philadelphia, 23 per cent.; Greater Berlin, 19 per cent.; Buenos Ayres, 40 per cent.

The city is on the right bank of the River Plate, a sloping bank 50 or 60 feet above the level of water, rising up to considerably greater elevations in the center of the city. It is about 120 miles from the sea at Montevideo. Its area is one of the greatest in the world, 44,830 acres; Paris has only 19,280, Berlin 15,625, Hamburg 15,681, and Vienna 13,690. It would be a good day's journey to go around the city, as its perimeter measures 39 miles.

So far as the natural conditions permit, the streets are laid out in the form of a chessboard, and are generally about 360 feet apart from center to center. In the central part of the city the streets are narrow; it is difficult for three carriages to pass. There are, however, a few 33 feet wide, and one or two avenues about 100 feet.

The finest, and said to be the best-lighted street in the world, is the Avenida de Mayo, which is in the center of the city as to the numbering of the houses north and south. It has a fine asphalt pavement and double electric lights in the center. It was cut through the blocks a few years ago, from the Casa de Gobierno (Government House), near the port, to the thirteenth street, somewhat less than a mile. At the other end there is being built a beautiful Capitol Building that will cost about $5,000,000 (gold).

There are seventy-two parks and small areas outside the main streets, with a combined area of 1,400 acres. These parks are more tastefully laid out and more neatly kept than can be found in any other country in the world, Paris excepted. In fact, in many respects the city, in its streets, lights, parks and structures, resembles Paris, except that there are more one-story residences than in Paris. The prevailing style is Spanish, with a patio (a kind of open area) and the rooms all facing it, and in this patio a garden and fountain, when the proprietor is able to have it; if not, pots of flowers very much like the city house in Mexico. The style of the houses of the wealthy may be seen on Avenida Alvear.

The pavements are wood (nearly all hard, suitable wood of the country), asphalt, granite blocks, macadam and rubble. No city has better pavements in the central part. In the outskirts, however, much of the pavement is very bad and uneven, merely rubble, but immense sums are being expended in substituting rubble for granite blocks and asphalt.

There is no city anywhere with more lines of street-cars; in fact, with the exception of two streets, there is a line in every one of the principal thoroughfares. And leading out to the pleasant suburban towns—Belgrano, Palermo and Flores—there are electric lines similar to those in American cities, using the overhead trolley. In fact, all the equipment, from rails to trolley, comes from the United States. Very extensive changes are being made in all parts of the city, substituting horse-cars, for electric. There are now 275 miles of street-cars which carried, in 1900, 116,447,982 passengers.

There is a project and a national concession for a system of underground electric tramlines, connecting the three main railway stations with the Plaza Victoria and, in one direction, extending by a surface line far out in the country. If underground lines pay in any city in the world they will in Buenos Ayres, for the conditions are especially adapted to their easy construction, the material being suitable for tunneling, and a great mass of people crowded into the "center" with its narrow streets, where the present surface

movement is often extremely congested. A citizen of the United States has the concession.

In 1868 there was a terrible epidemic of yellow fever, due, in a large part, to unsanitary conditions, but immediately afterward the city began a very extensive system of water and drainage works costing $33,000,000 (gold), discharging the sewerage 15 miles distant, and the storm waters by great intercepting sewers, now being completed, into the river in front of the city. The city water-works take their water above the city where it is never contaminated. These works were designed by Messrs. Bateman and Parsons, engineers, of London, and the main constructions carried out under their supervision.

The water of the River Plate is healthful but muddy, and it is clarified in settling-basins before being delivered to the distributing reservoir built on one of the highest points of the city. This distributing reservoir is a work of art, covered with glazed tiles over pressed brick. These works altogether have made Buenos Ayres one of the healthiest cities in the world, as the death-rate proves.

Ten years ago, upon the completion of the main works, the mortality per 1,000 was 30, now it is 16½. This compares very favorably with other large cities. London has 19·2, Glasgow 21·6, Liverpool 26·3, Manchester 24·1, Dublin 30·4, Paris 20·1, St. Petersburg 24·7, Vienna 20·7, Madrid 30·1, Rome 17·6, Venice 22·8, New York 18·4, Philadelphia 18·6, and Brussels 17·9. The Government is soon to extend the works at a cost of $5,000,000 (gold).

The climate, taking the whole year round, is equable and very agreeable. The parks are always green; vines and palms and a species of banana plants are seen everywhere, and flowers all the year in the open. It has a semi-tropical country in the north and in Paraguay from which to procure the plants, where the Victoria Regia and other beautiful plants grow wild.

In reference to education, the primary education is compulsory from the age of nine to fourteen; the secondary education from fourteen to nineteen is optional, as also the university or higher education from nineteen to twenty-five

or twenty-six. No man can enter into any of the professions, including engineering, and take a prominent position in the Government without being a graduate of the National University and having taken the course outlined in the above division of ages.

In 1900 there were 450,000 pupils in the public schools, which are free to all, and free to people of all religions. Although the Catholic religion is the national religion, neither it nor any other religion is allowed to be taught in the schools.

In the National University there are four faculties—law, and social science, medicine, exact physical and natural science, and philosophy and letters. In 1901 there were 3,562 students in the university.

In reference to religion, everywhere in Argentine under the Constitution all may worship God freely, according to the dictates of their own conscience. While the Government itself, like the Governments of Great Britain, Germany, Switzerland, etc., recognizes an established Church and assists in its maintenance, it also often assists in any benevolent and educational work undertaken by other denominations.

A very important work of this kind is the Argentine Evangelical Schools, initiated, promoted and carried on by Mr. William C. Morris. The report of 1901, just issued, shows there were 1,820 pupils in the various departments; in the previous year there were 1,076. This school is really a national school, and is assisted in a measure by Congress, although largely dependent upon private subscriptions, which are made to it not only by Protestants, but leading Catholics as well. It is devoted entirely to the education and care of children of the poor who cannot enter the public schools for want of suitable clothing.

The general style of the city is cosmopolitan, in buildings, in stores, in residences, in dress, in habits and customs of the people. It is made up of many nationalities. According to the census of 1895, there were in the country about 3,000,000 Argentines (all children born here of foreign parents are Argentines), and about 500,000 Italians—by far

the largest number of immigrants, and they are far better than the immigrants of the same nationality that come to the United States. Some of the best and most intelligent people in all kinds of business and industries, especially in agriculture, are Italians; next come the Spaniards, about 200,000; next the French, somewhat less than 100,000; next the English, 22,000; next the Swiss, 15,000; and lastly, the North Americans, as we are called, 1,400. These figures refer to the year 1895; the number of foreigners in the country December 31, 1899, was 1,199,808, an increase of 20 per cent. on the returns of the year 1895. Immigrants in the last forty-four years, 1,935,077; Italians, 1,198,550; Spaniards, 361,074; French, 162,636; British, 34,031.

The history of the lighting of streets in the city is very interesting, and shows that the city keeps pace with others in this respect. The first record of public lighting was in 1778, when the city had lamps in the shape of a tin of horse-oil with a wick, then came tallow dips, then oil-lamps, then came gas in 1885, and in 1888 electricity began to replace it in part, and on December 31, 1900, the city was lighted with 889 arc-lamps, 318 incandescent of sixteen candle-power, 14,084 gas lamps, many with the Welsbach burner, and 8,590 kerosene lamps, and there were thirty-six electric-light stations, with a capital of $9,000,000 (gold), and with a capacity of 23,300 electric horse-power.

In addition to telegraph lines there are four cable companies working with Europe and the United States, keeping up a close connection with all parts of the world, though the cost of cabling is quite heavy—$1 (gold) per word. The service is very good and prompt; its time of transmission between Buenos Ayres and London, "via Galveston" and Western Union lines and cables, is about sixty minutes, and with New York thirty minutes. When we consider the distance and the route, we are astonished at the working of this line, which crosses over the Andes 12,000 feet above the sea level, tunnels under the snow and avalanches and reaches the Pacific Ocean, only to take successive leaps by loops along the Coast to Tehuantepec, in Mexico; over the Isthmus, across and under the waters of the Gulf of

Mexico to Galveston, speeding then its swift flight over the poles of the Western Union to New York City; and then, without stopping to rest, plunges into the depths of the Atlantic Ocean and talks to the receiver in London in sixty minutes after it left the operator's fingers in Buenos Ayres. By a wonderful invention of recent years, this message has passed from ocean to land many times and back to ocean without stopping, through a "human relay," a machine worked by a human being.

It is an interesting fact that the difference in level between the highest point on land of the lines of the Central and South American Telegraph Company and the lowest point of its cables in the Pacific Ocean is about 31,000 feet (6 miles).

This company has three underground cables which cross the Andes and work uninterruptedly, notwithstanding that they are covered with snow, in some places at great depth, for about eight months of the year.

The house-fronts, when kept in repair and painted, are neat and architecturally beautiful. The words "repair" and "painted" must be explained. There are no wooden houses, which these words might imply; they are almost always made of rough brick covered with what is called "revoque," a covering of plaster or "staff," and sometimes artificial stone. The better class of houses generally have a base of granite, marble or other natural stone 3 or 4 feet high, and then brick covered with revoque. Sometimes the natural stone extends to the second story, and then invariably comes the artificial covering; after a while, two or three years, this begins to discolor and flake off, requiring painting and repairing; after ten years it begins to become an "eyesore," and at the end of twenty years it must all come off at very considerable expense. An instance to be cited is the American Church, Methodist Episcopal, which was built twenty-five years ago, but for five or six years past it has presented such a dilapidated appearance, that it has become necessary to remove the revoque from the sides and front from the base to the steeple, and renew it at a cost of $10,000—a large sum for a poor church.

A question came up recently about the Congress Palace just mentioned, as to what should be the external covering of this grand structure. Fortunately, the commission of engineers to pass upon this and other qestions decided upon a marble covering, and their decision was approved by the Government.

One of the finest constructions now being finished, after standing incompleted for ten years, is the beautiful Theatre Colon, which, through the kindness of Mr. Meano, the architect (who is also the architect of the Congress Palace), I am able to show you from some slides he has sent me.

The means of locomotion about the city are abundant—street-cars everywhere, and a very good and economical cab service. There are few coupés, no public hansoms and only one or two private ones; but the street carriages are two-horse victorias which carry four people. The private turn-outs are equal to those of any city in the United States, especially the horses, which are of the best imported stock. The "Corso" and the approaches to it on a Saturday or Sunday afternoon are very attractive. It is in the beautiful park of Palermo, one of the suburbs, broad avenues, beautiful shrubbery, lakes and shady drives, and immediately in front the broad River Plate, whose further shore is beyond the horizon.

The people show great taste in the arrangement of their stores, and particularly the shop-windows; from a butcher's shop to a confectioner's and a lace store, the fine French taste is visible everywhere. A walk along Florida, the principal shopping street, a fine asphalt street with no street-cars in it, is one of the delights of Buenos Ayres, and one never tires of it. If, for a fortnight, you miss this promenade, you hardly know the street, for the appearance of the stores has greatly changed in the meantime by a complete change of the decorations.

The manner of living is continental, not even English—a cup of coffee with a roll in the early morning; breakfast at 11 to 12.30 (which is a meal in courses), and dinner at 7.30, the principal meal of the day. This is the custom among all classes, high and low; and there is another custom (it is

strange how soon you fall into it): tea or coffee or matte—a species of steeped herb (yerba) pressed into a peculiar little bowl and sucked out of it with a hollow stick called a matte stick. This 4-o'clock drink is as necessary as any meal. In the Government House (Casa de Gobierno) the Government provides tea or coffee for all of its officials and employees, and little rooms are seen in various parts of the building, where it is made and served from, always accompanied with some kind of delicate biscuit.

Perhaps some current prices may be of interest, remembering always that, to get the price into American money, you must take only four-tenths of the price to allow for the discount.

Foreign letter postage is 15 cents per ½ ounce (6 cents).

Domestic letter postage, 5 cents per ½ ounce (2 cents).

Telegrams for the first ten words, 5 cents (2 cents), and the successive words 3 cents (1·2 cents). Telegrams in any other language than Spanish, double price. Address and signature are counted, as in Europe.

The usual fare for a victoria is a dollar (40 cents gold), whether you take it by the course or by the hour.

The foreign debt of the National Government in 1900 was $336,771,614 (gold), and the internal debt $3,222,500 (gold). There are thirty different loans, the interest on which ranges from 3½ to 6 per cent.; the total interest charge per annum in 1900 was $22,349,900.84 (gold). It requires annually to pay the interest on the total debt $18,661,864 (gold) and $11,695,218 (paper). The annual charge per each inhabitant is about $6 (gold).

It is generally known that in 1897 a terrible financial crash came upon the country, at the time of the Baring failure; since then it has had to struggle to carry the load imposed by the disasters of those days; however, perhaps not more disastrous than happened to Chicago in 1893, as many will attest who were caught in the Columbia National Bank failure and others.

What language is spoken? Spanish, which is the national language; but, as might be expected in a cosmopolitan city, French, Italian, English and German are spoken almost everywhere, particularly French.

As English money and Englishmen have done more than any to develop the country, have built and run nearly all the railways, many of the great estancias and other businesses, particularly commercial, the English language is very generally used in railroad and navigation circles.

With these general characteristics of the country and the Capital City, I must give you a brief résumé of the ocean commerce which has done so much for the country, and situated as it is, at these antípodes of the world, so necessary. First, a few dry facts and then the description of commercial facilities.

In 1899 the value in gold of goods imported was about $117,000,000, exported $185,000,000. Of these, $44,000,000 imports came from Great Britain, and $15,000,000 from the United States; Italy comes next with $14,000,000 and Germany next with $13,000,000, then France with $11,000,000 and Belgium $9,000,000. But exports show a different distribution, for France took $41,000,000, Germany $29,000,000, Belgium $24,000,000, Great Britain $22,000,000, the United States $8,000,000 and Italy $5,000,000. Of the foreign trade, Buenos Ayres had 87·2 per cent. of the imports, Rosario 8·8, La Plata 1·2 and Bahia Blanca 0·80. Of the exports, Buenos Ayres had 55·5 per cent., Rosario 18·4, La Plata 2·30 and Bahia Blanca 7·00. These ports are mentioned, as some information about them is needed to explain the commercial situation. Of all the goods reaching the River Plate countries, 80 per cent. comes to Argentine.

In 1885 the National Government began the construction of very large docks at Buenos Ayres; hitherto, all the business had been done from the anchorage, about 12 miles from the city, the intervening space being a great mud-bar, the water from a depth of 25 feet gradually shoaling to the shore-line at the city. This was so flat that it was necessary often to transfer the passengers and goods from the lighters, with which they had come thus far from the vessels, to steam launches, then to small boats and then to great wheel-carts, that went out a long distance in the water to meet the boats.

The new docks are very extensive, and lie along the

immediate front of the city and connected with it; they were designed by the well-known English firm of engineers, Hawkshaw & Hayter, and carried out under the supervision of Mr. James Dobson, the resident engineer and partner of the firm. The concessionaire was an Argentine citizen, Mr. Madero; the contractors were the experienced firm of Walker & Co., who built the Manchester Ship Canal. These men deserve the highest credit for carrying through, under the financial difficulties of the period above mentioned, a great public work costing $38,000,000 (gold).

In order to reach the docks from the sea, a channel had to be evacuated in the mud foreshore from the anchorage. This channel (the north one) is at low tide 21 feet deep and 330 feet wide and about 5½ miles long from its intersection with a channel which already existed by previous dredging from the other end of the port, at the mouth of a small sluggish stream called the Riachuelo, in which channel there generally was about 19 feet of water at low tide. The tide of 2 or 3 feet, depending largely upon the direction and force of the wind and very uncertain, permits vessels drawing about 23½ feet to enter the port by the north channel. The new port was connected with the older port, and now both channels are being used, and the depths in them are about as I have stated.

The Government has recently begun the extension of the north channel straight out to the anchorage, and later will deepen it to 22 feet. In the meantime, the navigation uses a crooked channel beyond the intersection, which has been partly dredged, curving round from the south channel to the anchorage. The depth of water in the northern entrance basin of the port is 21 feet, but in the four great docks, 23 feet, with tidal gates, so that the vessels at low tide may be afloat.

The works are built in the most substantial manner—masonry walls founded on what is called "tosca" (loess), the hard substratum that is found in this part of the country. The four docks, or basins, are from 620 to 750 yards long and are all 170 yards wide, connected by passageways 22 to 27 yards wide, over which pass, by hydraulic turn-

ing bridges, the foot, vehicular and rail-traffic. A sea-wall in front protects the entire port. On the city side are three and four-story brick warehouses, twenty-four in all, with a total frontage of $1\frac{1}{2}$ miles. Sheds, cattle-yards, railroad tracks, hydraulic cranes and capstans and other important appurtenances give the port modern facilities for handling cargo.

When the docks were opened at the southern end in 1899 the registered tonnage of vessels arriving and departing at the port of Buenos Ayres was 3,800,000; in 1901, 8,661,299—more than 100 per cent. increase. There are only twelve ports in the world of greater tonnage, and none of them show such phenomenal growth.

In 1880, about the time that the works were proposed, the tonnage was 644,570, and the plans were made for 2,000,000 tons only.

The extraordinary growth of the commerce has made it necessary to make an enlargement of the facilities, and this was one of the works intrusted to me during the last year of my stay in Argentine. I am able to show you the general plan of the actual port with the proposed enlargement, which will have free access from the sea and a depth of 26 feet.

The plan also provides facilities for "inflammables"—petroleum, gasoline, naptha and some explosives.

The Standard Oil Company, of New York, is now arranging to bring bulk oil in tank steamers to Argentine, and the Shell Transport Company is preparing to make a specialty of the importation of fuel oil from Texas and the Dutch East Indies. The work of enlargement of the port is divided into sections, so that it can be carried out section by section, as the increase of commerce will require. The general plan also includes the protection and deepening of the entrance channels.

One of the principal ports of the country is Rosario. Ocean navigatiôn reaches it, and, for that matter, reaches Colastiné, the port of the city of Santa Fé, the capital of the province. The registered tonnage of the Port of Rosario in 1899 was 3,000,000, of which more than 2,000,000 were over-

sea vessels—about 700 per annum. The merchandise entered and cleared was about 1,650,000 tons. Sixty-seven per cent. of the exportation was wheat. In the busy months there are often over thirty vessels seen at one time along the wharves and the barranca, where the wheat is loaded in bags, sliding down from the high cliff 60 feet above the vessel, in what are called "canaletas." The imports amount to about $10,000,000 (gold), and the exports to $30,000,000.

The National Government is making a great port of Rosario, endowed with all modern facilities for handling cargo. It sent out to Europe and the United States a full report, with all necessary data, submitting the project to capitalists and contractors, with the request for propositions to build and operate the port. It will cost from $10,000,000 to $12,000,000 (gold).

The contract, after an examination of and report upon the projects presented by a board, of which I had the honor to be president, has been let to the well-known and experienced firm of contractors, Messrs. Hersent, of Paris, associated with Schneider & Co., of Creusot—the Krupp of France. The works of construction were inaugurated by the President of the Republic, on October 26, 1902.

The plans of the work have been based on the data above mentioned.

Some important problems had to be solved in connection with the improvement of so great a river as the Paraná, the bed of which is subject to such important changes, and also its islands and banks.

The front-line of the proposed wharves is over 2½ miles long. The masonry piers must go down into the tertiary sand below the scour of the river, and their foundations will be from 60 to 80 feet below the low-water level.

The importance of this work, furnishing a modern seaport to the second city of the country, can scarcely be overestimated. In my report on the project made in September, 1900, I used the following words, which two years of subsequent study have corroborated:

"It is safe to say that the establishment of a first-class port at Rosario, with suitable channels of access, will revo-

lutionize completely the commerce and industry of this Republic."

I can now show you some interesting views of the river, the shipping, the canaletas carrying grain, the grain piles and some of the more important buildings of the city. All the plates made on the best American glass and by an American photographer, Mr. F. P. Danforth, of Boston, who has lived many years in Rosario, and I may add that many other slides shown you to-night were made for me by him.

La Plata port and city were built by the Provincial Government, when, in about 1880, the National Government came to Buenos Ayres to occupy it as the capital of the nation. It is an excellent port; it is built on the shore of the Rio de la Plata, about 35 miles from Buenos Ayres, and cost about $14,000,000 (gold). The opening the national port at Buenos Ayres has drawn most of the commerce from La Plata, but it is capable of being made, with a comparatively small sum of money, deep enough, in its entrance channel (5 miles long) and in its port areas, to accommodate vessels of 26 feet draught at low tide; it now has 21 feet.

The remaining port of importance, and rapidly growing, is outside the River Plate, in the South—Bahia Blanca; it is the principal shipping port of agricultural products by the Great Southern Railway, the largest system in the republic. This port is in an estuary of the ocean, and is a protected harbor; in fact, the terminal of the railway is about 35 miles from the open ocean. The railway is building a steel pier, 1,640 feet long, with spacious warehouses and 19 miles of sidings; and there will be, when all works are completed, over half a mile of wharf frontage supplied with electric cranes.

The National Government is building in this estuary at Puerto Militar, or Puerto Belgrano, a system of dry-docks and basins on a large scale. The first dry-dock, one of the best and largest in the world, is completed and now in use. It was designed and built under the immediate supervision of the well-known Italian engineer, Chev. Luigi Luiggi, who had charge of similar work at Genoa.

This dock, built of first-class materials and upon the most

modern methods, can take the largest naval or merchant ships of the world, as it has a useful length of 713 feet, and an entrance width of 85 feet, and a depth over the sill of 32½ feet at mean high-tide. It has intermediate gates, so that two or three small vessels can be docked at the same time or separately.

I cannot here go into details of construction, which were fully given in a paper on the subject submitted by Mr. Luiggi to the Ninth International Navigation Congress, at Düsseldorf, July, 1902. He has very kindly given me over thirty lantern slides, of which I can show you a few to give you a general idea of the dock. The plans, photographs and, possibly, a relief model of the dock will be exhibited at the World's Fair in St. Louis, in 1904.

In October last the U. S. Battleship Iowa, the flagship of the South Atlantic Squadron, was docked at Puerto Militar.

You will be interested to know that at Buenos Ayres there is a large business with New York by means of five steamship lines, and through New York with Chicago and other cities, from which are shipped a large amount of agricultural machinery of all classes, from cultivators and plows to great steam threshing-machines of the J. I. Case Company, of Racine, Wis. Not only from Chicago, but from all manufacturing districts, the trade of our country is quite rapidly increasing. You see our machinery everywhere, and it is everywhere considered equal to any—Baldwin locomotives, Jackson & Sharp cars, and Harlan & Hollingsworth's. The American freight-car of 25 and 30 tons is replacing the old Belgian, French and English 7 and 10-ton cars. If the American cars are not all made in the United States they are exactly copied from ours. The most approved bridges are from the United States. I have been over several, and examined one on the Transandine Railway, built by the Phœnix Bridge Company—excellent bridges and giving entire satisfaction. The Boston Bridge Company sent out some very good bridges; the horse-cars, by John Stephenson & Co., of New York; electric-cars, by the J. G. Brill Company and the Westinghouse Company, are doing well there. Large quantities of Southern and Oregon pine are imported.

From the United States comes all the kerosene used in the country. I might go on enumerating many other United States products. I can well say that the prospects of American trade with Argentine are exceedingly good.

The total population of Argentine, 1902, is about 5,000,000; so that, as you see, about one-sixth live in the capital city.

I would like to enter into the work of the engineers, but cannot now. I may say, however, that the Argentine Government is determined to improve the great rivers of the country by methods which have been found to be best in other countries under similar conditions. The results of our experience upon the Mississippi are being closely watched, studied and applied. The reports of the Mississippi River Commission are of great value to that country. I may further say that the engineers, and the methods pursued by them, are equal to those of any country. Every Government engineer, to take a prominent position, must have a diploma from the Engineering Department of the National University. The graduates of this excellent school are as well equipped for their work as those from any school in the world—this I know by experience, for four of them (young men) have been associated with me as my immediate assistants; and in my position as Consulting Engineer of the Government I have been brought into close relations with many other engineers, and I have the highest opinion of their ability.

I will now select at random a few subjects of special interest, and a few lantern slides.

The Government Building—Casa Gobierno—sometimes called the "Casa Rosada," from its light-rose color, and in which was my office, is one of the most prominent buildings in Buenos Ayres.

It stands in a prominent and central position, facing the Avenida Mayo, and looking out on the other side over the port and the River Plate.

One of the finest structures in Buenos Ayres is the "Prensa" Building, devoted entirely to that morning paper. I know of no newspaper offices in the world that can com-

pare with this in elegance and convenience in all its interior appointments.

The leading newspapers of Buenos Ayres are equal to any, both in editorial ability and in telegraphic news from all parts of the world.

The Sarmiento School gives me an opportunity to call your attention to one of the most learned and best of presidents, who, when he was Minister at Washington, became so enamored of our country, and particularly our educational methods, that he engaged a large number of our young lady teachers to go to Argentine as Normal School teachers. Many of them are there yet, after nearly twenty years' service—a service that has reflected honor upon themselves and their country.

An institution of importance is the Jockey Club, for by its influence the Argentine blooded stock of horses has been made equal to any in the world, and its domicile is one of the finest and most expensive of any club-house in existence, and its stand at the race-course of Palermo is a beautiful structure.

Some views of Recoleta, the principal cemetery, will show you the general method of burying the dead.

Before closing this lecture, it is right for me to say that considerable of the statistical data was obtained from "The Argentine Year Book," just issued for the first time (1902), and that some of the hydraulics are from a contribution to that book written by myself. The Annual can be obtained from the Moorgate Publishing Company, of London.

You may properly ask me why I have brought before you the subject of Argentine. I can easily reply: First, because in two years of close relations with the country, and especially with the Government officials, I formed a very favorable idea of the character of the people and of the possibilities of business and profitable enterprise for our own people there; and, second, because the high officials of the Government and leading men of the country desire to have the "North Americanos," as we are called, come to Argentine with their business energy, integrity and ability, and their capital as well, to help build up and move forward to its high

destiny that great country of South America, so like our own in its climate, soil, rivers, coast-line and other general features.

If I have succeeded in interesting you in Argentine, and of giving you more knowledge of it than you had before, I shall be satisfied with my efforts and feel that I have done a service to that country and to my own, and I will close by introducing to you General Roca, the President of the Argentine Republic.

FURNACE GAS ENGINES.

The construction of gas engines to burn the gases of blast-furnaces probably represents even more important economical changes than those for utilizing either natural gas or producer and illuminating gas. Germany has held undisputed supremacy in the development of this form of engine in the past few years, and we are just beginning to profit by her experiments Engineers look to the German operators for their designs and tests with the blast-furnace gas engines, but now that they are perfected it will not be long before a complete change will be effected in this country. With our numerous blast-furnaces scattered all through the country, it is essential that the installation of engines to utilize the waste gas should be made at once. The gas engine of 1,000 horse-power is no longer a dream. It has been steadily developed and improved by the tandem system, so that it can be operated by blast-furnace gas of but 27 calories per cubic foot. As as result of this development, the blast-furnace suddenly assumes an entirely new line of development. It may be that the production of pig-iron will in the near future become only of secondary consideration, and the gas for operating engines the chief factor of the works. The blast-furnace gases are sufficient to run powerful engines even when discounting half for waste and for heating the air-blast of the furnace.

The amount of gas generated by a blast-furnace to produce pig iron is so enormous that if collected and utilized for power purposes it would prove revolutionizing in manufacturing industries. Thus to produce in an ordinary well-equipped works about 150 tons of pig iron, the blast-furnace would generate upward of 20,000,000 cubic feet of gas. To harness this enormous amount of waste fuel is the aim of the builders of gas engines. Utilized for generating steam by burning, about 1,000 horse-power could be obtained; but if burnt directly in a modern large gas engine, the horse-power generated would be several times as much. Eminent engineers estimated that even if half this volume should be wasted or used for heating the air-blast of the furnace, there would still be sufficient to produce between 3,000 and 4,000 horse-power. Such an enormous gas generator would thus prove of the greatest value for ordinary manufacturing purposes. Likewise, the gases of coke ovens can be utilized in the same way, adding greatly to the importance of the gas engine in its new field.—*Iron Age.*

Mining and Metallurgical Section.

Abstract of a paper presented November 20, 1902.

On the Industrial Importance of Metallography.

By Albert Sauveur.

The lecturer, after expressing his belief in the industrial importance of metallography, said that he was fully aware that many who had only a very superficial and fragmentary knowledge of the subject were inclined to question its practical side. He hoped that he would be able in his short talk to present such arguments as would be, if not conclusive, at least suggestive of its commercial application. As he had been prevented from preparing a paper on the subject, he hoped his hearers would extend to him the indulgence of which he was in need. It was possibly best to assume that some of the persons present did not even have a rudimentary knowledge of metallography, and to shape his remarks accordingly. Time would not permit to consider other metals than iron and steel.

The lecturer used a number of enlarged photomicro. graphs to illustrate his remarks. He first called attention to the structure of pure gold, which consisted of irregular polyhedric grains, stating that all pure metals exhibited a structure of this character, the size of the grains, however, varying with different metals and also with their treatment, especially with the temperature to which they were heated and with the rate of cooling.

Passing to the structure of pure or carbonless iron, it was shown that this metal also was made up of irregular polyhedric crystalline grains, its structure being very similar to that of gold or to that of any other pure metal. It was noticed, however, that some of the grains were dark while others were bright, and this was shown to be due to the fact that each grain is made up of a great many small cubic crystals which have the same orientation in the same grain

but are differently oriented in different grains. Those grains which have their small cubic crystals so oriented that they will reflect the light in the tube of the microscope will appear bright, while if the light reflected by the small crystals fails to enter the tube of the microscope, the corresponding grains will appear dark. It was seen, then, that iron and other metals were composed of crystalline grains, each grain being made up of a great number of small true crystals, frequently cubic.

Passing to the microstructure of wrought iron, it was shown that it also consisted of a mass of crystalline grains, but that the structure included beside numerous particles of slag. In a section cut in the direction of the rolling or forging of the iron bar, these slag particles ran parallel to that direction imparting a fibrous appearance to the metal. In a cross-section, however, the slag occurred in the shape of irregular small areas corresponding to the cross-sections of the fibers exhibited in the previous diagram. It was thought for many years that wrought iron actually had a fibrous structure and, indeed, the number of persons still holding this view was surprisingly large. Many valuable properties were attributed to puddled iron on account of its "fibrous structure," which were denied to steel because of its "crystalline structure." The microscope had summarily disposed of this erroneous belief in showing that the carbonless iron constituting the bulk of wrought iron was just as crystalline as the carbonless iron constituting the bulk of soft steel.

Carbonless iron considered as a microscopical constituent had been called *ferrite*. In introducing a small amount of carbon in the iron, say 0·10 per cent., and in producing it molten so as to obtain it free from slag; in other words, in converting it into soft steel, the structure underwent an important modification: the bulk of it was still made up of ferrite but it contained besides a number of small dark areas which necessarily must contain all of the carbon present in the metal. These dark areas, however, do not consist of pure carbide of iron, for upon higher magnification the constituent is resolved into two components: it is made

up of parallel plates alternately dark and light. These plates consist of ferrite and of the carbide, Fe_3C. This carbide had been called *cementite*, while this new constituent, consisting of a mixture of ferrite and cementite, was called *pearlite*, because of its pearly appearance. A number of photographic enlargements were exhibited illustrating the structure of pearlite.

Upon increasing the amount of carbon in the steel, the amount of pearlite increased and that of ferrite decreased, correspondingly. When the iron contained about 0·8 per cent. of carbon, the ferrite had entirely disappeared, the metal consisting then entirely of pearlite. Upon a further increase of carbon, the steel still consisted of a mass of pearlite, but particles of pure cementite were now present which increased in proportion with the carbon content, while the pearlite decreased correspondingly. The rationale of the structure of steel could evidently be explained as follows: All the carbon present in steel entered in combination with some of the iron to form the carbide Fe_3C which contains 6·67 per cent. of carbon. This carbide or cementite formed a mechanical mixture with some of the iron, in the proportion, roughly, of 1 part of cementite to 7 parts of iron (ferrite), assuming the shape of pearlite. If an excess of iron was left over, it was present in the structure as ferrite, and this would be the case with low carbon steel: if, on the contrary, an excess of the carbide was present it was found in the structure as free particles of cementite.

Passing to the microstructure of cast iron, the lecturer showed that perfectly gray iron was composed of a mass of ferrite throughout which was distributed numerous particles of graphite, while white cast iron had the structure of a very high carbon steel, being made up of pearlite and a large amount of cementite. It was, indeed, not possible to draw a sharp line of demarcation between high carbon steel and white cast iron. The structural changes occurring in the structure as the carbon increased was a very gradual one, from the softest steel to the hardest grades and finally to white cast iron. It was then shown that when gray cast iron contains a small amount of combined carbon, the matrix

of the metal contains a small proportion of pearlite—in other words, it consisted of low carbon steel; as the carbon increased in passing gradually from the perfectly gray to the white variety, the matrix or metallic part of the metal underwent exactly the same changes which had been shown to occur in steel under similar conditions. Cast iron consisted of a mass of steel plus a certain amount of graphitic carbon. The lecturer took exception to the oft-repeated statement of some writers referring to the great complexity of cast iron as compared to steel, and expressed his belief that if cast iron was viewed in its true light, it would greatly help in solving many puzzling problems.

The close relations between the structure of steel and its treatment on the one hand, and between the structure and the properties on the other, were then dealt with somewhat at length, the lecturer illustrating his remarks by photographs of the same steel which had been subjected to a number of different treatments. The composition of the metal had not been changed, and if given to the chemist the latter would have had to report that the various samples, from a chemical standpoint, had the same properties. Their properties varied greatly, however, and were closely related to the appearance of the structure. This demonstrated the limitations of chemistry and the assistance which may be expected from the microscopical examinations in all questions relating to the treatment to which metals are subjected; and it was of as great importance to impart the right structure to a metal as to secure for it a desirable composition. The harm resulting from a defective structure was as great as that resulting from a defective composition.

Concluding his remarks the lecturer stated, that if any one, in taking up metallography, expected that he would be able to solve all his daily troubles, and to solve them at once, he would be disappointed; but that if the study was taken up in a more reasonable frame of mind and conducted intelligently, it could hardly fail to prove of very great assistance.

The lecture was further illustrated by the exhibition of some stereopticon slides. The necessary apparatus to carry on metallographical work was exhibited, the lecturer being

greatly indebted to the Ajax Metal Company and to the Cramp Shipbuilding Company for the loan of apparatus.

DISCUSSION.

MR. P. KREUZPOINTNER.—Mr. Chairman and Gentlemen: It is a great pleasure for me to corroborate all that Professor Sauveur has said about the use of the microscope in examining metals, so far as its practical value is concerned to the expert, in a variety of ways where the chemical analysis and physical test fail to give us a satisfactory explanation of certain phenomena.

I have used the microscope for the past eighteen years, and I consider its use as valuable and indispensable an addition to a physical laboratory as the plane is to the carpenter, or the micrometer is to the machinist. I do not share the optimistic view, though, of some, that in the near future we may be able to use the microscope as a substitute for the chemical analysis or the physical test. There is such an endless variety of conditions that affect the structure of, say, a piece of steel, which might lead the microscopist to judge that, with the change of structure, a change in the physical quality, or ability of a given steel to do a given piece of work, has taken place. Such an assumption, however, does not hold good, as two pieces of steel of different structure may and do give the same tensile strength, and the one which is inferior often gives a better elongation even, due to greater stretch at the point of rupture and less stretch along the section. Thus, in my opinion, and judging from experience, it will be some time yet before we can tell the working qualities of steel without other means than the microscope. Moreover, even then, whenever we should reach that desirable point of perfection and simplicity in method of determining the qualities of metals, for a long time to come there would be but a few experts who would be able to do so with reliability, since the determination of the quality of iron and steel for their physical ability to resist the forces of destruction, requires long experience and the opportunity of everlasting comparison of metals of all kinds and of all makes, new and old, made by the same

manufacturer at different times, or different manufacturers at the same time For these reasons the microscope, valuable and indispensable as it is, as an auxiliary to the physicist, will not become a substitute for the tensile test for a long time to come, although the tensile test is not by far so reliable as many engineers assume it to be. The best and most reliable service the microscope has done thus far, and is destined to do still more so in the future, is in the determination of the heat-treatment of steel and the composition of alloys which have not yet undergone mechanical treatment.

With the hammering or rolling of metals a complexity of conditions arise, to determine which requires a greater variety of means and personal practical experience. Concerning the question, subsequently raised, whether the appearance of the coarse fracture of a piece of steel, or rather metal, that is of the fracture as it originates by nicking and subsequent breaking, or breaking in service, bears any relation to the micrograin or microstructure underneath the fracture, I do not believe there is any relation between the respective layers or planes of the metal sufficiently well defined that we could draw conclusions from the appearance of the fracture to the microstructure below, or the succeeding plane of the metal.

In order to allow us to draw conclusions from the fracture to the microstructure underneath, we must assume that the distortion of the particles or crystals of the metal, caused by the rupture, would continue deep into the metal, so that succeeding transverse planes of the metal exhibit the same amount and nature of distortion, which then will be the micrograin in question. If we assume that no distortion of the particles takes place during rupture, which, however, is inconceivable, since in that case we would have to assume that there was no resistance offered by the metal to the force of rupture, then still the appearance of the ruptured surface would be so much different to the naked eye than the micrograin underneath, that we are not warranted to draw any conclusions more than to say that the metal underneath is fine or coarse-grained.

From what experience I have in regard to this question, I would say that the distortion, caused by rupture, does not go beyond that amount of metal which we have to file and grind off in order to get to the plane of metal below the rupture plane, and, therefore, what we see in that plane with the microscope is not what we see in the grain of the ruptured surface of the metal. The unreliability of conclusions drawn would, of course, be the greater the farther we go away from the point of rupture, because of the variations of microstructure we are apt to find in any piece of commercial metal in its various portions or sections.

MR. W. R. WEBSTER inquired whether the appearance of the fracture of a piece of steel, as seen by the eye, corresponds with that under the microscope?

MR. ROBERT JOB:—In answer to Mr. Webster's question whether the appearance of the fracture of a piece of steel, as seen by the eye, corresponds with that under the microscope, I am satisfied that in the large majority of cases it does do so. In other words, when the fracture appears to the eye coarse-grained, the steel has a coarse microstructure. It has been our experience that the converse is not invariably true. A case in point came under our observation several years ago in making drop-tests upon a lot of rail-butts. All had been rolled under the same conditions throughout, yet, when fractured under the drop, some showed a coarse granular fracture while others appeared to be relatively fine. Sections were removed from some of the latter, and they were found to have the coarse, open, microstructure characteristic of that rolling. Therefore, I feel that deductions from an apparently fine-grained fracture may be totally at variance from the actual structure, and that the fine granular form may be merely incident to some peculiarity in the conditions of fracture.

When the fractured surface is filed smooth and etched, the granular appearance, as viewed by the unaided eye, is relatively the same as when seen under the microscope, and a general estimate may often be made without the aid of the glass.

MR. G. H. CLAMER:—The structure of alloys presents many of the characteristics exhibited by cast iron and steel. In fact, we may regard these as alloys of iron with varying amounts of carbon, silicon, manganese, etc. One of the most simple examples by way of comparison is the lead and antimony alloy, which has by experiment and microscopic examination been shown to consist of dendrites of pure lead embodied in a eutectic of lead and antimony, if the content of antimony be below 13 per cent.—the saturation-point of these two metals. As in steel, free ferrite is contained in diminishing proportions from pure carbonless iron up to ·89 per cent. carbon. Just as from pure lead to the alloy of 13 per cent. antimony, or thereabouts, is the free lead present in diminishing proportions. At 13 per cent., so-called eutectic alloy, lead is saturated with antimony, antimony is saturated with lead. No free lead is present, no free antimony. As the proportion passes the eutectic composition, free crystals of antimony make their appearance. Here again we see the analogy to steel, which segregates above the saturation-point of· 89 per cent. carbon-free cementite.

Another interesting example is the alloy of copper and tin, which has, perhaps, a little more complex composition. Alloys rich in copper (above 73 per cent.) consist of dendrites of pure copper eutectic and chemically combined copper and tin, generally conceded to be of the formula $SnCu_3$. The above alloy, 27 per cent. tin and 73 per cent. copper, is the first eutectic, the high tin-content alloy forming another. The formation of these eutectics exhibiting themselves constantly in the everyday manipulation of alloys has a very practical bearing on foundry practice.

I once met with a very peculiar demonstration of the presence of copper and tin eutectic in casting phosphor-bronze, a composition which contains 79 per cent. copper, 10 per cent. tin, 10 per cent. lead and 1 per cent. phosphorus. This metal was cast into connecting-rod bushings for locomotive construction. The castings showed on the outside a thin skin of metal about the thickness of paper, which could readily be detached from the casting, showing

it had been forced to the surface through pores after the body of the casting had solidified. The composition of this was about as follows—I cannot locate the exact figures:

Copper	70	per cent.
Lead	3	"
Tin	22	"
Phosphorus	3	"

thus showing perhaps a quadruple eutectic, or, at any rate, a tendency toward the copper-tin eutectic—27 per cent. tin and 73 per cent. copper.

Another curious thing in connection with this was the presence of 3 per cent. phosphorus, showing the fact discovered by Charpy, that phosphorus is localized in the eutectic.

Another curious phenomenon coming daily under my observation is the formation of eutectic on top of compositions, such as the above, in casting ingots. An alloy of metal, when apparently solidified, will often have appear on its surface what we term eutectic sweats, because it sweats or oozes out in thin streams apparently through pores, and forms globules on the surface. These globules are hard and brittle, and entirely dissimilar to the main portion of the ingot, the analysis always showing a high tin alloy, although the original may contain but 5 to 10 per cent.

I can heartily endorse this apparently new method of investigation, for which Professor Sauveur has done so much in this country, and can say that its field of usefulness is not confined solely to the province of iron and steel, but can be extended also in a practical way to the manufacture of metallic alloys.

PLATINUM EXTRACTION IN THE URAL REGION.

Professor Demaret-Freson has lately published some interesting facts in regard to the production of platinum. Within the last few years the applications of this metal, especially in the electrical industries, have rapidly increased, while the production remains about stationary, and it is estimated that the entire world's production is not over 7 tons annually. It is owing to this cause that there has been a considerable rise in the price of platinum.

The metal is generally found in alluvial layers of sand and gravel near the water-courses, in the bottoms of valleys or on the hillsides. It generally occurs in the form of flattened grains with either a rough or smooth surface. Nuggets are also found, but these are more rare. Russia furnishes about 96 per cent. of all the platinum produced. It is found especially in the Ural region, the most productive locality being in the government of Perm. The placers are situated on the crest of the mountain chain or on the two sides. On the European side they lie along the rivers Vilva and Kava and along the Otka and other streams. Many of the rich placers lie in the domains of Prince Demidoff, and on one occasion a nugget was found there which weighed 22 pounds. The platinum-bearing strata are often 15 feet in thickness, but as they are often sunk as low as 60 feet below the surface, they must be reached by a series of shafts and galleries. On the Asiatic side are found the gold and platinum-bearing sands of the Miass River and other streams of the region. The richest deposits yield from 60 to 90 grains of platinum per ton, while this proportion varies down to 40 grains The metal is generally found along with gold in most of these regions, and both are extracted by a somewhat primitive method. When the material is of a clayey nature, it is charged in a barrel-shaped wooden receptacle about 6 feet high and 8 feet in diameter, whose bottom is covered with perforated sheet-iron. Into the cylinder is fed a number of streams of water from a pipe which encircles the mouth. In the center turns a vertical shaft carrying a series of arms which support iron bars for working the material. In this way a muddy deposit containing the metal sinks to the bottom and passes out through the holes; it is run on to an inclined table or shallow trough 3 feet wide and 10 feet long, in which are retained the platinum grains. In other cases, when the material is sand or gravel, a simple cylindrical sieve is used instead of the cylinder and, like it, is supplied with streams of water.

When the placers are found in the river-bed or in submerged ground, the peasants employ a primitive method of dredging. Mounted on a raft, they operate a wood scoop through an opening in the center. The scoop is on the end of a pole 12 feet long, and is brought up by a chain wound on a windlass. The sand and gravel are poured on a sieve which is mounted above a kind of cradle placed on the raft itself; it is fed with water from a hand-pump. The material obtained by these processes is further enriched by a second washing, and the platinum is separated by treatment with mercury, which amalgamates with the gold but does not attack the platinum, and the residue containing the latter is sent to the refineries. The residue obtained in the Ural region contains on an average 87·25 per cent. platinum, 1·20 of rhodium, 0·05 of iridium, 0·01 of osmium, 1·04 of palladium, besides 1·50 of osmium iridium alloy; it also contains 8·40 of iron and 0·55 of copper. To extract the platinum from the mixture, the wet process is generally used; it is treated with aqua regia, and the solution thus obtained is precipitated by chloride of ammonium in the form of a double chloride. The latter is calcined and the resulting product may contain 99·9 per cent. of platinum In some cases the electric method is employed to separate the platinum from the iridium and rhodium. A rather weak current is used, the electrolyte being an acid solution of platinum chloride.—*Scientific American Supplement.*

Section of Photography and Microscopy.

Stated Meeting, held Thursday, February 14, 1903.

Under and Overexposure.

By John Bartlett.

There is undoubtedly truth in the saying, "a fellow-feeling makes us wondrous kind," so far, at least, as photographic experience is concerned, for we all sympathize in the disappointment of those who fail from the one cause of improper exposure of plate. At the risk, therefore, of being laughed at for uttering a photographic truism, we would hint at the paramount importance of correct exposure. Notwithstanding the confidence some have in depending upon the so-called latitude of exposure, we are of the belief that this latitude is within very narrow limits.

There is demanded a correctness in estimating the time of exposure, if any regard is had to the beauty or brilliancy of the result.

To the inexperienced eye the effect of a slight deviation from correct exposure may not be perceptible in the resulting negative, but to the trained eye a very slight excess of timing is apparent in the solarization of the high lights and the clouding over of the shadows, which become more or less emphasized in the print.

Correct exposure, therefore, should be the aim of the photographer, and we are inclined to think that this *desideratum* is attained only by exercise of judgment gained by experience. For one acquires, by observation of the varying effects of light upon a variety of subjects presented to the camera, a sort of photographic sense which serves him in future experience. There have appeared from time to time many ingenious attempts to reduce the time of exposure to rule. Instruments have been constructed and tables calculated to guide the inexperienced.

Far be it from us to speak disparagingly of any means promising to put exposure on a scientific basis, so as to

reduce to exactitude our photographic work; but personally we, after trial, have found them wanting.

The conditions under which subjects must be photographed vary so considerably, not only as regards light and shade, but with the character of the subjects, that any attempt at calculation would involve the consideration of so many factors as to preclude any systematic arrangement, and would contribute rather to the confusion than to the edification of the novice.

A record of personal experience is of more value in training judgment than implicit reliance upon exposure-meters or tables. Nevertheless, it may be urged that judgment is liable to err, and mistakes may be even made by the experienced, which it may be desirable to counteract in development.

If the time has been correctly estimated and the developer tempered thereto, any one may work out the plate's salvation without fear or trembling; but when the personal equation of under or overexposure is taken into consideration, the evolution of the perfect negative becomes really a fine art, and foreknowledge and acquired skill are demanded if one looks for softness without smear, high lights distinct and well defined, and shadows full of detail going by imperceptible gradations into the lights.

How shall this knowledge of proper adjustment be acquired? By experience we have said, not by mere dosing with bromide of potassium, deluging with water or spurring with alkalies, nor by feeling one's way with the leading-strings of tentative development.

Some start out on the very cautious track; thus, not knowing the exposure, they say let us bring out the detail with weak pyro or eikonogen or other agent, and then pile it on afterwards to build up by intensity.

Others say, start with the minimum of alkali, and if undertiming is evident, then apply the increments of alkali. By both plans experience attains good results, and the votaries claim that their special method is the only practicable method of manipulation.

But "there will come a time some day" when your ten-

tative method will be found wanting. To get good results, we ought to diagnose the plate's exposure and determine whether the case demands a direct method in development or a tentative method, and apply a special therapeutic.

We hardly appreciate the resources we have in our phalanx of modern developers. We know a good deal about their action but take little advantage of their special agency, thinking that they may be used indiscriminately.

Pyro is still a faithful ally in many cases, especially for obtaining plucky, vigorous negatives with rich shadows; but when great detail is demanded, and we are not sure that ample time for shadows has been given, it would be unwise to cling to it and try to force detail by excess of alkali when better results may safely and effectually be obtained by one of the other reducing agents like metol, for instance.

Suppose we wish to develop an exposure in which we have certain colors which unequally affect the sensitive film—that is, we desire to equalize the action of light impressed upon a plate not orthochromatic. It certainly would be unwise to employ a strong development, which would cause the rush of particles to the parts most acted upon by light and give the negative the appearance of an undertimed plate. No. We should rather make use of a well-diluted developer in which the alkali was somewhat in excess of the reducing agent.

But how are we to treat an enforced short exposure? We must seek for a developer which shall work out all the detail which the light has impressed. For really we are of the belief that it is not so much the failure of the brief impact of light on the silver molecules to produce effect as it is the inability of the developing agent to marshal them to its calling. We believe that any, no matter how brief, action of light produces a molecular change, and it is only the want of a proper reducing agent to make the action of the light manifest. In other words, if we had suitable developer we might evolve an image made by the briefest possible exposure. So it is by very short exposures we are apt to get very contrasty negatives if we are not exceedingly cautious

in our methods of development. Where the action of the developer is slowed, there is a more harmonious distribution of particles, and consequently a greater range in gradation of light and shade than could be obtained by a rapid development. Any agent, therefore, which is slow in its action recommends itself for short exposures. Glycin, an agent but little used simply on account of its tardiness in evolving the latent image, is preferable for undertimed plates.

The advantage of glycin over pyro and others is that with short exposures it gives less dense high lights and richer shadows—that is, its slow action equalizes the distribution of light and shade.

Various agents have been employed either as retarders, restrainers or accelerators of the action of the developer in calling forth the latent image.

We are familiar with the use of potassium bromide as a corrective of overexposure. It is, indeed, a valuable accessory to development, but its injudicious use frequently results in the production of harsh, contrasty work, inharmonious in light and shade.

Citric acid has been suggested as a restrainer in place of potassium bromide. When the modern developers are used, it will be found that a 10 per cent. solution of the acid gives greater power of restraint and less contrasty effect than bromide, and, besides, not materially affecting the duration of time of development. Sugar, in the form of weak syrup, is also employed to restrain hasty action of developer.

Among the accelerators of the action of the developer, the writer has found iodine of especial advantage. A developer with iodine may be made as follows:

Water	3½	ounces
Sodium Sulphite (granular)	62	grains
Hydroquinone	15	grains
Saturated Solution Sal Soda	2½	drachms
Bromide Potassium, 10 per cent.	10	drops

To this solution is added 3 drops of iodine solution made with—

Water	4½	drachms
Iodide of Potassium	77	grains
Iodine (scales)	20	grains in 8 ounces water

This accelerates development of undertimed subjects in a remarkable degree, and the resulting color of the image is richer and more intense than without the use of iodine. The addition of iodine, even in slight excess above that recommended, is liable to cause fog and reduction of density.

Hypo has also been used as an accelerator (1-1000), very dilute, of course. In some cases it may be found beneficial, but the writer has not noted any special advantage from its use.

We have spoken of the advantage of slow development for undertimed plates and of the employment of diluted solutions. Indeed, some operators employ exceedingly diluted developing solutions for snapshot work in the form of what is called "tank development." The plates are placed vertically in a bath and covered with a solution containing only a small quantity of developing agents—so small a quantity that it is necessary for the action to be continued a long time to produce good results. The writer has subjected plates very much undertimed to a developer so constituted that it required twelve hours to obtain satisfactory negatives. Pyrogallic acid seems to lend itself best to this mode of development, as it may be diluted to a great degree without losing its energy; its action is only slowed down. Of course, there is danger of encountering stain by prolonged exposure of film to pyro, and it is necessary to employ an increased amount of sodium sulphite in the bath. Edinol, one of the late additions to the list of developers, may also be greatly diluted without appreciable loss of energy. It must be used in connection with sulphite of soda, but there is less liability to stain than with pyro.

AMERICAN INVENTION IN 1902.

The report of the Commissioner of Patents for the calendar year 1902 shows a total of 49,490 applications for patents, including designs, and that 27,776 patents, including designs, were issued. In addition there were 110 patents reissued, 2,006 trademarks registered, and 767 labels and 158 prints registered. During the year 23,331 patents expired, 4,471 applications allowed were forfeited because of non-payment of fees, and 9,284 allowed applications are still awaiting final fees. The excess of receipts over expenditures was $159,514.

FORMATION AND MALADIES OF PEARLS.

Pearls are concretions formed of carbonate and phosphate of lime, associated with a small quantity of animal matter. They are produced by various acephalous mollusks. They consist of very thin layers of mineral matter, arranged in such a way as to give rise to the phenomena of interference, producing that brilliancy and orient which have made them sought for in all ages as objects of adornment.

Their origin and formation have been much discussed. Without recounting all the poetical legends to which they have given existence, naturalists seem to infer that they may be formed in any part of the mollusk. This notion is erroneous.

All pearls are formed by the mantle, and it is only afterward and by accident that they are found in other parts. The examinations of the *Unio* leave no doubt in this respect.

The identical chemical composition of the internal nacreous layer of the valves of the mollusk and of the pearls corroborates this view.

The walls of a bivalve shell are composed of two layers, each having a special origin. (1) An epidermic layer, produced on the border of the mantle, and forming its organic continuation. (2) An internal layer, composed of very thin lamellæ, secreted by the external surface of the pallial envelope.

The first of these layers increases the periphery of the valves; the second augments their thickness.

It is in consequence of a lesion, or the presence of a foreign body, organic or inorganic, that a depression is produced in the pallial surface, with a hypersecretion of nacreous matter, forming concentric layers around the foreign body as a nucleus. The concretion, thus formed, usually remains at first adherent to the pearly layer of the corresponding valve and separates from it later, becoming free. This action of the pallial surface explains the process employed by the Chinese for the production of small nacreous bas-reliefs. It is sufficient to introduce the surface to be pearled between the mantle and the internal face of the shell, making the reverse of the relief adhere to it in some way.

Pearls can ordinarily be preserved for long periods without change. However, they may become *sick*, that is, undergo various modifications, causing them to lose the qualities on which their value depends.

These maladies are spontaneous or acquired. The first consists of a sort of disaggregation of the superficial layers produced slowly, and in the end destroying the brilliancy and orient of the pearl. It is possible to remedy the evil, at least for a time, by the removal of the affected layers, either by a chemical process or by mechanical polishing.

The acquired maladies are produced by prolonged or repeated contact with the skin, whose acid secretions and sebaceous matter exert a deleterious influence. They may also occur from the influence of gaseous emanations, sulphydric acid in particular. Pearls in time acquire a slight amber tint, which is far from diminishing their value; but when this tendency exceeds a certain limit, they become blackish, the organic matter being modified by the causes that have been mentioned. I know of no remedy then for the sick pearl, and believe that its depreciation is inevitable.—*M S. Jourdain in Sci. Am. Suppl.*

Strength of White-Iron Castings as Influenced by Heat-Treatment.*

By A. E. Outerbridge, Jr.

In the year 1882, while engaged in metallurgical work at the car-wheel foundry of A. Whitney & Sons, in Philadelphia, my attention was called by the inspector of wheels to an unusual and remarkable change that had occurred in the chilled or white iron forming the "treads" of a number of wheels poured from one heat. This change was first observed on removing the wheels from the annealing ovens. It was customary for the inspector to prove the hardness of the chilled treads by testing them with a cold chisel all around the "throat" or place where the tread joins the flange. On this occasion he found a number of wheels which were quite soft on one portion of the rim, extending the entire width of the tread for a length of 6 or 7 inches, while on either side of the soft spots the chilled tread was so hard that the steel chisel slipped over the surface without biting. In order to study the nature of this singular occurrence I caused the wheels to be broken through the soft spots so as to examine the fracture, and I found that the white iron (chilled iron) had been changed into perfectly gray iron, evidently after the wheels had been cast. The change was not equally well marked in all of the wheels and the soft spots were smaller in area in some cases than in others, but in all, the dividing line between the white portion and the gray portion of the chilled tread was sharply defined.

It is perhaps necessary to state that in the establishment where these wheels were cast it was customary to pre-heat the annealing pits by means of soft-coal fires before the wheels were lowered into them, the flames passing through the pits or ovens. The rule was to close the dampers just

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* Read at the fifth annual meeting of the American Society for Testing Materials, held at Atlantic City, June 12, 13, 14, 1902.

before the pits were opened to receive the red-hot wheels, in order to shut out the flames.

After careful investigation, I found that through an oversight the dampers of the annealing pits had not been closed and the flames from the fires impinged upon the surfaces of three or four red-hot wheels in the lower part of each pit, causing a complete change of the carbon from the combined form to the free condition wherever the flames touched the castings.

Drillings were taken for analysis from the soft parts of the chilled treads and also from other parts of the wheels, as well as from test-pieces poured from the same ladles of iron. The analyses showed two things—first, that the car-wheel iron was of normal composition; second, that the only change in the metal of the annealed or soft portion of the "chill" was in the condition of the carbon, which had been converted from chemical combination with the iron into an amorphous form of graphitic carbon, or, to speak more guardedly, I would prefer to say simply into the form of "free" carbon, for there are reasons for believing that the carbon in this case is not in the same condition as when it exists normally in gray iron.*

Specific-gravity tests showed that the gray cast-iron resulting from this accidental heat-treatment of white iron differed materially in density from the normal gray iron forming the unchilled parts of the same castings; the specific gravity was about 7·80 as compared with specific gravity of

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* Through purely chemical methods four conditions have been detected:

(1) Graphite or free crystallized carbon, not acted on by acids even when concentrated.

(2) Graphitic carbon or "temper-carbon," which is also in a free state and unaffected by acids, but presenting an amorphous appearance.

(3) The carbon of the carbide of iron (cement carbon) forming a definite compound, acted upon by concentrated acids, but insoluble in diluted cold acids. This carbide answers to the formula Fe_3C.

(4) Hardening carbon, which appears to form a solid solution with the iron (or which is perhaps present as a compound dissolved in the iron) and which is acted upon by cold, dilute acids.

"Notes on the Chemical Constitution of Cast-iron and Steel." By A. Carnot and E. Coutal.

Annals des Mines, October, 1900.

about 7·20 for the normal gray metal; a cubic foot of the gray iron produced by this annealing process therefore weighed about 37·5 pounds more than a cubic foot of the normal gray iron of the same casting. It was noticed that the fracture was of much finer grain than normal gray iron, and "chips" or drillings of the annealed chilled iron differed greatly in appearance, size and shape from the chips or drillings of the normal gray iron made with the same drill.

Several metallurgists, to whom the pieces of annealed chilled iron were exhibited, offered a plausible explanation of the phenomenon, saying that it was merely an accidental conversion of the white iron into malleable iron, and therefore presented no novel features. The analyses quickly showed the fallacy of this theory, for the total carbon was the same after annealing as before annealing, being about 3½ per cent. in each case, while in the ordinary conversion of white-iron castings into malleable iron, a large part of the carbon is removed by the oxidizing material in which the castings are imbedded when subjected to heat-treatment, and this conversion of white iron into malleable iron can only be successfully accomplished on sections of metal of moderate thickness, say less than 3 inches.

Although this accidental discovery of annealing of white iron on the treads of car-wheels was regarded as an interesting and novel one at the time, the only practical use made of it was to guard against a repetition of the accident in the annealing pits of the car-wheel works with which I was at that time connected.

After the lapse of several years I was called upon to investigate in a professional capacity, and in the interest of some prospective investors, the merits of a new process of converting white-iron castings into steel, and received from the manufacturer a number of axes, hatchets and other edge tools, which had been cast in white iron and subsequently converted into a metal having evidently many of the qualities of steel.

Without describing in detail the process to which these white-iron castings had been subjected, I may say, briefly,

that they were placed in the muffle of a furnace together with a chemical compound claimed to be necessary to the conversion of the cast-iron into steel. Common salt and crude hydrochloric acid were two ingredients of this compound. The similarity between this process and the accidental over-annealing of the car-wheels (with consequent change of the condition of the carbon) suggested to my mind that the chemical compound was probably unnecessary and that the secret consisted solely in the heat-treatment, and I so advised my clients.

The conversion of white-iron castings into dense gray iron having high tensile strength (approximating that of certain grades of steel) capable of being hardened and of taking a sharp cutting edge is no longer a secret, and is carried out on a commercial scale in a number of establishments. While I cannot speak positively, I am of the opinion that the heat-treatment alone is now relied upon to produce the desired results. These products are *not* steel castings, though sold in some instances under the name of steel; neither are they malleable iron, but they may be described as occupying a peculiar position midway between cast-steel and cast-iron.

Having given a résumé of the history of this process of heat-treatment of white-iron castings, I will state a few facts regarding certain interesting features, including tensile strength of this converted metal. In the early experiments I found that there was a vast difference in white irons, some samples remained white and hard after having been soaked for many days in the annealing furnace, even when subjected to the highest temperature below the melting-point of the metal, while other specimens of white iron of the same dimensions yielded readily to the heat-treatment and became completely converted into gray iron in a few hours at a comparatively low temperature—analyses of the different samples revealed the chief cause of this difference; it depends almost entirely upon the presence or absence of silicon in the white iron; castings containing only a trace (or a few tenths of 1 per cent.) of silicon cannot be successfully treated, for only a partial change of the combined

carbon into free carbon takes place, even after prolonged treatment at the highest temperatures. Thus, in one of my tests, two white-iron bars, about 2 inches in diameter and 12 inches long, were placed side by side in the furnace and subjected to the heat-treatment for eight hours. One of the bars, containing about 0·15 per cent. silicon, was cast in sand; the other, containing 1·25 per cent. silicon, was cast in a heavy iron mold, because, if cast in sand, it would not have been white iron. Both bars were equally brittle, equally hard, and perfectly white before treatment; a slight tap with a hand-hammer was sufficient to break them. When removed from the furnace after eight hours soaking at a high heat, and allowed to cool in the air, the bar containing 0·15 per cent. silicon was unchanged in the appearance of the fracture, while the bar containing 1·25 per cent. silicon was almost gray; it was soft and so ductile that a small piece of it was flattened out under the steam-hammer while cold. The bars were then returned to the furnace, subjected to the same heat-treatment for six hours longer and allowed to cool, as before. No visible change occurred in the low silicon bar, while the other bar was completely converted into gray iron with a uniformly fine-grained fracture and dark-gray color. This bar was turned in a lathe to a diameter of 1·129 inches (giving an area of 1 inch) and provided with threaded ends for the grips of the testing-machine. The metal was readily machinable and the surface was free from "graphite pits" so characteristic of ordinary soft gray iron when machined. This bar was pulled on a hydraulic testing-machine of 100,000 pounds capacity, and the actual load at failure was 47,760 pounds. The elongation and reduction of area were not measured, but were very small.

A number of similar tests were made on different sized bars, giving tensile strengths ranging between 40,000 pounds and 50,000 pounds per square inch, but manufacturers equipped for making converted castings in this way have obtained much higher records than these.

The literature upon this novel and interesting subject is very limited, but some valuable papers have been published

and it is my desire to present herewith a résumé of the work done by several well-known metallurgists in this country and in Europe.

At the meeting of the Mining and Metallurgical Section of the Franklin Institute, held June 9, 1897, Mr. Charles James described "A Special Process for Treating Cast-Iron," the following account of which appeared in the *Journal of the Franklin Institute* of July, 1897:

"White iron, with approximately 2·40 per cent. combined carbon and 0·4 per cent. graphitic carbon, is used for the purpose. The castings are placed in a muffle furnace, in which they are subjected to the action of a secret composition (said to be a powerful volatile oxidizing agent) and maintained at a temperature slightly below fusion for five or six hours. The product may be forged and tempered and shows a remarkable increase in tensile strength. The total carbon in the product seems to be the same as in the untreated iron, but combined carbon has been substantially altered into a finely disseminated uncombined carbon.

"Doubts were expressed in the discussion which followed, whether the result was not due entirely to the annealing, rather than to the 'medicine.' The prolonged annealing was thought to be a sufficient explanation of the facts. The process is in commercial operation in a large foundry in Philadelphia, producing hatchets, hammers, etc."

The *Journal of the Franklin Institute* for September, 1900, contains an article by Mr. James on the subject, giving abstracts of results obtained from daily business practice, extending over a considerable period of time; but though these investigations were made for the guidance of commercial operations, they seem to be of sufficient metallurgical interest to justify their presentation.

Mr. James states that the irons used were all of Bessemer quality, the melting charges consisting of a mixture of gray and white irons, of which the following is an average analysis:

	C.C.	G.C.	Si.	Mn.	S.	P.
White iron	3·50	·50	·50	·20	·08	·08
Gray iron	·50	3·50	1·30	·30	·02	·03

"The composition of the charges was regulated by the silicon content, which was made to vary from 1·20 per cent. to ·90 of 1 per cent., the average chemical composition of these mixtures being:

	Per Cent.
Carbon	3·40 to 3·80
Silicon	·90 to 1·20
Manganese	·35 to ·20
Sulphur	·05 to ·04
Phosphorus	·04 to ·03

"The iron was sometimes smelted in a cupola, but generally in an air-furnace. The following is the average chemical composition of a large number of castings:

C.C.	G.C.	Si.	Mn.	S.	P.
3·02	·47	·78	·12	·05	·04

The weight of the castings ranged from a ½ ounce to 2,000 pounds and over. The time required to effect the change varied from three and a half to ten hours from the time the castings had attained their full temperature.

"The temperature at which the change takes place in castings of this description lies between the melting-point of silver and copper, and may therefore be approximately taken at 1,850° F.

"The change of carbon in castings subjected to the annealing process, though gradual, is co-extensive throughout any given cross-section of the casting; no hard center or core of white iron, surrounded by softer metal, having ever been observed in any of the castings examined. No matter at what period the annealing may have been arrested, the total surface of any fracture always showed a similarity in the condition of the metal, provided the composition of the metal was homogeneous and the heat-treatment had been applied equally to all parts of the casting."

This agrees perfectly with my own observations, and it constitutes, moreover, a very interesting and important feature, differing from malleable-iron castings, where a progressive change occurs; the central portion of a malleable-iron casting is sometimes found to be practically unaffected by the heat-treatment as to the total carbon, and unless the casting is very thin, the conversion is in fact never uniform

throughout the section. The same law of progressive change in the proportion of carbon obtains in "case-hardening" of steel, though the operation is the reverse, *i.e.*, carbon is imparted to, instead of withdrawn from, the metal.

The following analyses before and after annealing, given by Mr. James, show very clearly, that the only change effected by the heat-treatment is in the condition of the carbon:

	C.C.	G.C.	Si.	Mn.	S.	P.
Before annealing . . .	2·60	·72	·71	·110	·045	·039
After annealing	·82	2·75	·73	·108	·040	·039

Mr. James says: "I wish however to say that, although, for convenience, the term graphite is employed in stating the analyses of these castings after annealing, the condition of the carbon differs very materially from graphite, either as found free in nature or as solidified out from gray iron during cooling. . . . The carbon thus formed is evidently identical with what Ledebur has called 'tempering graphite carbon,' and is an allotropic form of graphite, and not merely amorphous carbon."

Mr. James states that both silicon and manganese exert great influence upon the carbon during the annealing process. "The presence of silicon being a necessary condition to the carbon change. In low silicon iron it is very difficult, and in some cases impossible, to effect the carbon change, no matter how long the iron is exposed to the heat-treatment."

My original investigations did not indicate that manganese possessed any very marked influence on the carbon change in this process, though I am well aware that manganese, especially in the form of ferro-manganese, added in very small quantity to molten car-wheel iron, exerts a marked effect upon the chill and on the relative proportion of combined and graphitic carbon. It is a fact, however, that low silicon irons are usually low in manganese, and this, I think, is the reason why Mr. James was led to infer that manganese facilitates the carbon change in the annealing process.

Mr. James gives no records of strength of the white-iron castings converted by him into gray iron by annealing.

Before proceeding to the consideration of other features I desire to call attention in passing to one point which may, I think, have practical value, especially in the manufacture of chilled cast-iron car-wheels.

It has long been known that wheels having approximately the same depth of chill on their treads wear very differently in service: some retain their hard surface until the white-iron tread is gradually worn away evenly all around the wheel; others become soft in spots very quickly, necessitating removal from service long before the wheel has lived its proper life.

We know that the action of the brakes on the wheel heats the tread, and it seems to me not unlikely, from the foregoing observations, that when the silicon exceeds a certain amount, say 0·7 per cent. in any wheel, a similar kind of annealing of the white-iron tread of the wheel may occur from the heating action of the brakes, thus changing the condition of the carbon, at least to a partial extent, causing the chilled tread to become much softer than would happen under similar conditions where the wheel is made of metal containing less silicon.

The most recent investigations bearing upon the subject under discussion corroborate the prior observations fully, and may be found in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, Paris, March 31, 1902, under the title, "Sur l'Equilibre des Systemes Fer-Carbone," by G. Charpy and L. Grenet.

The authors call attention to the investigations of M. Bakhuis Roozeboom on an interpretation of known facts relating to the constitution of metals formed of iron and carbon, published in the *Bulletin de la Société d'Encouragement*, November, 1900, and also to the investigations of Hugh P. Tiemann on "The temperature limits for the separation of graphite from martensite in pure cast-iron," published in the *Metallographist*, October, 1901.

The authors say: One can believe, then, as appears to be admitted by Mr. Tiemann, that the abundant separation

of graphite, observed by Mr. Royston, was due to the presence of silicon in the white-iron castings employed.

We have made a great many experiments on this point, and we direct attention in particular to the results obtained on five samples of iron containing practically the same percentage of total carbon and in which the other elements are found only in small proportions, except the silicon which exists in variable quantities.

The following table gives the composition of these specimens:

No.	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.
1	3·60	0·07	0·03	0·01	trace
2	3·40	0·27	trace	0·02	0·02
3	3·25	0·20	trace	0·01	0·03
4	3·20	1·25	0·12	0·01	0·01
5	3·30	2·10	0·12	0·02	0·01

These samples had been poured into cold water and did not contain any appreciable proportion of graphite, except the last, where we found 0·20 per cent. Fragments were subjected to annealing, more or less prolonged, at different temperatures. Six tables are given showing the length of time of each treatment, the exact temperatures, and the proportionate change of combined carbon into graphite for each specimen.

The following conclusions are reached: they are announced didactically as laws and may be so accepted.

(1) The separation of graphite commences at a lower temperature as the percentage of silicon is increased in the iron.

(2) The separation of graphite having begun, it continues at a lower temperature than that required to commence the reaction.

(3) At a constant temperature the separation of graphite proceeds at a lower speed according as the temperature is lower and the proportion of silicon is less.

(4) The proportion of combined carbon which corresponds to the equilibrium at a given temperature diminishes when the silicon is increased.

(5) The brochure of Messrs. Charpy and Grenet is embellished with several fine photo-micrographs showing very

clearly the microstructure both before and after treatment. No records are given of tensile strength of the treated specimens and, as it is stated at the beginning of the paper that the white iron specimens were obtained by pouring the metal into cold water, tensile tests could not be made, for the samples were presumably merely small irregular lumps which are far inferior, I think, for such purpose to the uniform ingots of white iron obtained by pouring high chilling metal into heavy iron molds. I have found it easy in this way to obtain ingots of white-iron of any desired length and of suitable sections, the dimensions depending, of course, upon the proportion of silicon contained in the iron poured. By using a flat ingot mold made of thick cast-iron plates I have obtained flat ingots $5 \times 3 \times \frac{1}{2}$ inches of perfectly white iron and containing as much as 2 per cent. of silicon. These high silicon white-iron ingots or plates are very readily converted into gray iron by annealing.

Although I consider it a misnomer to call castings, such as hatchets, axes, etc., made from white iron changed to gray iron by heat-treatment and subsequently hardened on cutting edges, steel castings, they are certainly very different from true malleable-iron castings or from ordinary gray-iron castings, possessing qualities more closely resembling steel.

When the process is carefully and intelligently conducted the product is reliable, but prejudice has been developed by the fact that some of the manufacturers have not thoroughly understood the underlying principles and have turned out castings imperfectly converted. It is, of course, much easier to make perfectly white-iron castings from metal very low in silicon, but, as I have here shown, such metal is unsuitable for the subsequent conversion by heat-treatment into gray iron, and this I believe to be the main cause of many failures.

So far as I know there are no valid patents covering the process of heat-treatment of white-iron castings for conversion into dense gray iron of high tensile strength, capable of being forged and tempered, by simply changing the condition of carbon without removing any of the original component elements.

As the process of converting white-iron castings into malleable iron is well understood and has been carried out on a large scale for many years, I have not thought it necessary to allude to this product further than to show that it is radically different from the white-iron castings containing all of the carbon of the original metal before the heat-treatment. Good malleable-iron castings are ductile and may be bent almost double and twisted, while cold, without breaking, if the section is light enough to permit of complete malleableizing, but annealed white castings cannot be thus bent, even when completely converted into gray iron.

It is true, that since the discovery of the fact that hard and brittle white-iron castings may be changed by simple heat-treatment into strong soft gray-iron castings, some makers of malleable castings modify their old methods and practically rely upon heat-treatment to anneal their castings without placing them in oxidizing material, as formerly, to remove the carbon, but such heat-treatment does not and cannot make true malleable-iron castings. In other respects, also, converted white-iron castings, containing all of the original carbon, differ in physical properties from malleable-iron castings from which a large portion of the carbon has been removed.

In conclusion, I would say that if we can eliminate the false name of "steel" which has been given to converted white-iron castings, a distinct advantage will have been gained, for I believe that the new metal is worthy of taking a special place in the metallurgical arts, and I anticipate extended practical applications of the process as knowledge of the proper methods of heat-treatment and of the valuable properties (as well as the equally marked limitations) of the metal shall become better known and appreciated.

PHYSICAL SECTION.

Stated Meeting, held April 24, 1901.

The Contributions of H. F. E. Lenz to the Science of Electromagnetism.

By W. M. Stine, Ph.D.

PART I.

Modern science can scarcely be said to have found a place in its manifold activities for purely historical research of its true beginnings, and the subsequent experimental or analytical development of its fundamental subjects. Such a statement as this obviously can only be true when it is accepted in a wide sense; for the careful reader will at once recall much admirable historical matter woven more or less incidentally into treatises such as "Preston's Theory of "Heat" or "Light," where it forms an integral part of the discussion; or in a few choice monographs and memoirs; and again especially, German scholarship has supplied such historical works as Rosenberger's "Geschichte der Physik." Though for the general reader the usual historical treatment is commonly adequate, a more exacting person readily finds, upon looking up the historical development of almost any line in science, that the available information is by no means consecutive or sufficiently complete to enable the essential progress of the subject to be followed.

Selecting, as is done in this paper, the subject of electromagnetism, these general remarks are far more applicable to it than to inorganic chemical science, for instance, for reasons that are readily apparent. There have not lacked books of varied gradations of pretensions which have borne the generic name of "Electricity and Magnetism;" nor have definite histories of electricity been wanting, such as Albrecht's; and, if this were not sufficient, popular works, such as Trowbridge's "What is Electricity?" have insistently enforced their historical story upon the reader. And

Fleming, also, in the "Alternate Current Transformer," has essayed a partial history of electromagnetism; and not only are Faraday's researches available in greatest detail, but the reader has not far to go to find an almost equally detailed account of the experiments and conclusions of Joseph Henry.

Yet against all this may be brought the assertion that the essentially complete and philosophically considered history of the subject of electromagnetism remains to be written. The reason, if one need be sought for this condition, is at once apparent; the rapid development and extended applications of electromagnetism have continually absorbed all available knowledge of the subject for its own advancement, and have more or less completely diverted those fitted for the task from the scholarly labor of historical research to the more popular and alluring field of experiment and extension of the boundaries, real or supposed, of the subject.

Almost at the very outset of scientific historical study the reader is made aware of a singular tendency to be traced in the nomenclature with which he is dealing; and this tendency is the designation of the fact by the name of the discoverer of the phenomenon. It is now Ohm's law, or again Lenz's law that confronts the reader. He measures resistance with the Wheatstone bridge; or perhaps he uses a Kelvin balance or a D'Arsonval galvanometer. He can scarcely perform the simplest experiments without thus materializing the names of past or present worthies. However irrelevant this may seem at first, consideration will show that it is in reality germane to the subject.

The labors of the scientist lack much, or almost wholly, the expression of the individual. The architect may use his powers and acquired skill and the finished building will be the expression of himself through his craft; and it will be truly an expression of the individual, for the design partakes of his personal mode. No other could have designed just such a structure; the particular building could not have been constructed had he not had existence. This necessity for the expression of the individual is especially realized

for the author through the medium of verse; or for the artist as he embodies part of his own self in the statue.

With the scientist, the case is radically different. Nature is impersonal and the fact is not changed nor the phenomenon influenced by the labors of any student, or the experiments of any scientist. Perhaps these things are unconsciously recognized, even by the most mechanical and artisan-like scientist, and it is their recognition which has induced a partially organized reparation by the wholly artificial means of assigning the origin of any branch of science in particular to that one whose work stands first in point of time; very much as if the science were in any sense the product of the creative genius of the experimenter.

The history of science, however, fails to show that such a function exists between our knowledge of the facts of nature, and that one who has brought them to our notice. Almost invariably a fact of nature is suggested by some happy accident, and the scope of the development of the natural phenomena being necessarily limited, one man as well as another is able to guide the course of development. Even if the matter of discovery or development is in part intellectual and so anticipatory, the mental processes that lead on one investigator are not in their nature different from those possessed by other minds similarly trained and directed in attention, and equally skilled. Man, in other words, in the acquisition and extension of scientific knowledge, plays the part only of a recipient, and in no sense that of a creator; he can p!y the part of the manual or intellectual artisan, but in no respect can he attain to being an artist.

Ohm's law has already been offered in evidence. This law, which defines in what magnitude the current is a function of the electromotive force and the resistance, is obviously a particular instance of a perfectly general relation; and experiments with electrical currents could not have proceeded to any extent without revealing the necessity for such a law, and eventually establishing it. The individual experimenter phrasing and establishing such a law was simply the first one in point of time. Now, whether the virtue

of having been first in point of time will justify encumbering the spoken and written phrasing of a law with the name of an individual need not be enlarged upon, as it is too obvious.

This law was enunciated by Ohm in 1827;* but the relation was partially anticipated by Henry Cavendish in 1781† and perhaps by others; and it was certainly independently discovered by Joseph Henry.‡ So, whether Ohm had formulated this relation or not, the law would assuredly have been established prior to 1835. More recent instances are not lacking. The name of Hertz has thus far been inseparably connected with certain phenomena of the stressed field surrounding an electrical charge whose equilibrium has been disturbed. The researches of Hertz began at the suggestion of von Helmholtz in 1879 and were later resumed in 1886. Yet the phenomena were anticipated long before; and whether Hertz had developed our knowledge of them or not, the increased attention paid to alternating current phenomena would very quickly have led investigators to their full recognition. If nothing else had done so, the protection of long power lines against lightning would alone have discovered the Hertzian phenomena.

This unphilosophical and mistaken zeal has resulted in encumbering science with an extensive vocabularly of a reminiscent and biographical character. From the "Peltier effect" to the "Hall" or "Zeeman effect" is a monotonous list of these meaningless, terse and unintellectual symbols, which science would do well to expurgate from its technology.

The beginnings of the science of electromagnetism strikingly exhibit this phase of the impersonal character of scitific work; and if the development of this science is broadly considered, it shows convincingly how slight is the influence of the supposed genius of the investigator. In the history of this subject there is found a record of at least

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*G. S. Ohm, Die galvanische Kette mathematisch bearbeitet. Berlin, 1827.

†The Cavendish Researches, Arts. 574–5, 629, 286.

‡Consult Electrical Engineer, Vol. XVII, 1894, p. 297.

several persons making the same discoveries independently, and endeavoring to derive the same laws from the same trend and relations of phenomena involved. It seems that the germ of a new advance in thought, or a generalization, may be abroad and working in the minds of men, and is their common possession; it appears now in one place and again in another without any apparent common stimulus, which would be adequate to produce such a unity of affection. At the most the investigator, even of the highest talent, can but anticipate the labors of others by a longer or shorter period, can exhibit a little more enterprise and initiative than his fellows; but the facts and laws of nature will ultimately be possessed whether one man or another discovers them. The relation of the investigator to the development of science is rather that of the skilled and learned workman; and while honoring the labors of the investigator and acknowledging his essential relation toward the spread of science, it must be conceded that the real scope and play of genius is not in the experiment and investigation, but rather he is the genius *who builds upon facts the philosophical system of their laws.* In the subject of electromagnetism it is Clerk Maxwell who does this so voluminously rather than luminously, for the researches of Faraday and Ampere*, and Franz Neumann for the results of the work of Lenz.†

Among us the work of Lenz has not received the full recognition to which it is entitled. He is known in a very general way as the one who phrased the law bearing his name. Yet the relation which his work bears to the development of electromagnetism is so important that it merits, even at this late day, at least a brief presentation. To this end the present paper will endeavor to present an outline of the researches of Lenz and place these in their historical sequence or precedence, as the case may be, with the labors of those who are fully accredited with the discovery of the phenomena of electromagnetism. This effort was imme-

* Clerk Maxwell: Electricity and Magnetism; Vols. I, II.

† Die mathematischen Gesetze der inducirten elektrischen Ströme, 1845.

diately suggested by a monograph on the researches of Lenz, written by W. Lebedinsky, and published in the St. Petersburg "Electrichistuo" in 1895.* While the present account and estimate of Lenz and his work has been derived from his own published articles, yet the monograph by Lebedinsky has been consulted, that the writer may have the advantage of an estimate of Lenz's researches and contributions, made by a scientist of his own country and persuasion.

By many it has been accepted that perhaps all of the later developments and applications of electromagnetism may be attributed in point of origin to the illustrious investigations of Faraday, especially. But such a view is not supported by the facts in the case. As has already been stated, the phenomena discovered by Faraday were in no sense peculiar to the man, such that had he failed to ascertain them the world would inevitably have been the poorer for their lack. The immediate beginnings of the science of electromagnetism date back from the classical experiments of Oersted in 1819. When, after his famous experiment, it was understood that an electrical current would induce magnetism, the possibility of the converse action taking place seemed to have occurred to many scientists, and slowly to have matured to a conviction.

In order to appreciate the work of Lenz with exactness, something more is needed than the mention of its day and year in the succession of historical data of the discoveries and developments in electromagnetism. It will be necessary to revive something of the scientific atmosphere and feeling of those days, and to place the mind in sympathetic touch with the master-thoughts of those times which centered about the development of electricity from magnetism. To the contemporaries of Faraday, Henry and Lenz this conception was as pregnant with enthusiasm and expectation as the present-day thought of the direct production of electricity from carbon. For the writer no means of gaining the story of those days of wonderful discovery has been

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* Translated for the writer by Mr. Stone, of Chicago.

so vital and truthful as the reading of the simple narratives of experiments by which Faraday and Henry, especially, announced to the world the experimental demonstration of the scientific anticipation of those years. And since it cannot better be told, the original articles will be quoted here at considerable length. The account by Prof. Joseph Henry will first be given; not that preference is accorded him from national prejudice, but that he is more frank and generous in the recital.

The famous contribution* of Henry begins: "Although the discoveries of Oersted, Arago, and others have placed the intimate connection of electricity and magnetism in a most striking point of view, and although the theory of Ampere has referred all the phenomena of both these departments of science to the same general laws, yet until lately one thing remained to be proved by experiment in order more fully to establish their identity, namely, the possibility of producing electrical effects from magnetism. It is well known that surprising magnetic results can readily be obtained from electricity, and at first sight it might be supposed that electrical effects could with equal facility be produced from magnetism; but such has not been found to be the case, for although the experiment has often been attempted, it has nearly as often failed.

"It early occurred to me that if galvanic magnetism, on my plan (see Vol. XIX, *Silliman's Journal*, page 400), were substituted for ordinary magnets, in researches of this kind more success might be expected. Beside their great power, these magnets possess other properties, which render them important instruments in the hands of the experimenter—their polarity can be instantaneously reversed, and their magnetism suddenly destroyed or called into full action, according as the occasion may require.

"With this view, I commenced last August (1832) the construction of a much larger galvanic magnet than to my knowledge had before been attempted, and also made prep-

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*This was printed in the appendix to No. 2, Vol. XXII, of *Silliman's Journal*, October, 1832; the title was, "On the Production of Currents and Sparks of Electricity from Magnetism."

arations for a series of experiments with it on a large scale in reference to the production of electricity from magnetism. I was, however, at the time accidentally interrupted in the prosecution of these experiments and have not been able since to resume them, until within the last few weeks, and then on a much smaller scale than was at first intended."

Professor Henry then records the statement that he had read in the 117th number of the Library of Universal Knowledge "that the result so long sought after has at length been found by Mr. Faraday, of the Royal Institution." He then quotes in full the announcement from the April number of the *Philosophical Magazine*, under date February 17th, which is given below. He then continues:

"Before having any knowledge of the method given in the above account, I had succeeded in producing electrical effects in the following manner, which differs from that employed by Mr. Faraday, and which appears to me to develop some new and interesting facts. A piece of copper wire about 30 feet long and covered with elastic varnish was closely coiled around the middle of the soft iron armature of the galvanic magnet. (Described in Vol. XIX, *Silliman's Journal.*) The armature thus formed with wire was placed in its proper position across the ends of the galvanic magnet and there fastened so that no motion could take place. The two projecting ends of the helix were dipped into two cups of mercury and these connected to a distant galvanometer by means of copper-wire 40 feet long. This arrangement being completed, I stationed myself near the galvanometer and directed an assistant at a given word to immerse suddenly in a vessel of dilute acid the galvanic battery attached to the magnet. At the instant of immersion the north end of the needle was deflected 30° to the west, indicating a current of electricity from the helix surrounding the armature. The effect, however, appeared only as a simple impulse, for the needle, after a few oscillations, assumed its former undisturbed position in the magnetic meridian, although the galvanic action of the battery, and consequently the magnetic power, was still continued. I

was, however, much surprised to see the needle suddenly deflected from a state of rest to about 20° to the east, or in a contrary direction when the battery was withdrawn from the acid, and again deflected to the west when it was reimmersed."

On the first impression it may seem singular that the announcement of Faraday's success was so long a time in reaching the attention of Henry; but the transmission of news from Europe to America was slow in those days, and beside, Henry was then a professor at a small school, an academy, in the partly isolated town of Albany. As was his custom, he was in this year, 1832, engrossed in experiments during his vacation, and these he conducted in his schoolroom. Partly through preoccupation, partly owing to the slow diffusion of news and to having been at such a distance from a large center, it can be understood that the report of Faraday's success did not reach Henry until he was well on the way toward an independent discovery of the same phenomena. And to appreciate clearly the influence which the announcement could have had in guiding him experimentally, it is interesting to examine the terse extract published in the *Philosophical Magazine* * to which Henry refers in his own communication.† The note occurs in connection with a report of the proceedings of the Royal Institution, and reads:

"Feb. 17. *The Conversion of Magnetism into Electricity.*—This long wished-for result has at length been obtained by Mr. Faraday. If two wires *A* and *B* be placed side by side, but not in contact, and a voltaic current be passed through *A*, there is instantly a current produced by induction in *B*, in the opposite direction. Although the principal current in *A* be continued, still the secondary current in *B* is not found to accompany it, for it ceases after the first moment."

A touch of local history is not without interest in this narrative, and it shows to what extent scientists generally were interested in these remarkable phenomena. The en-

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* April, 1832, Vol. XI, p. 300.

† Also reprinted in *Silliman's Journal*, No. 2, Vol. XXII, October, 1832, p. 386.

thusiastic interest aroused by Faraday's announcement of his successful experiments was relatively as great as that so recently awakened through the Röntgen-ray phenomena. Prof. A. D. Bache, of the University of Pennsylvania, published in the *Journal of the Franklin Institute** a philosophical summary of Faraday's experiments and their extension through Nobili's researches; and what is more interesting, he prints two letters from a certain J. Saxton, of Philadelphia, which were written from London in April and May, 1832, to one Isaiah Lukens. Through these letters especially an insight is gained into the exact feeling which had taken possession of English scientists.

In coming to the recital of Faraday's work, he has not introduced so much of the personal element into the narrative of his experiments.† He is more scientifically formal, and prefaces his account with a definition of the sense in which he proposes to use the term "induction." After briefly referring to some phenomena of induction in magnetism and static electricity, he remarks:

"Whether Ampere's beautiful theory were adopted, or any other, or whatever reservations were mentally made, still it appeared very extraordinary, that as every electric current was accompanied by a corresponding intensity of magnetic action at right angles to the current, good conductors of electricity, when placed within the sphere of this action, should not have any current induced through them, or some sensible effect produced equivalent in force to such a current.

"These considerations, with their consequence, the hope of obtaining electricity from ordinary magnetism, have stimulated me at various times to investigate experimentally the inductive effect of electric currents. I lately arrived at positive results, and not only had my hopes fulfilled, but obtained a key which appeared to me to open out a full explanation of Arago's magnetic phenomena, and also to

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* July, 1832, p. 66.

† Read November 24, 1831, and published in the "Philosophical Transactions of the Royal Society," Part I, 1832, pp. 125–163. Also in Vol. I, "Faraday's Experimental Researches in Electricity," pp. 1–41.

discover a new state which may probably have great influence in some of the most important effects of electric currents."

Faraday's way to success in endeavoring to establish his preconceptions and hopes lay through many failures and partial results, while it may be recalled that Henry brilliantly proved his grasp on the same thought by one simple and decisive experiment, the like of which, it will be seen, Faraday had been led to in the end.

It seems that the thought of the generation of electricity from magnetism had materialized itself into a general experimental idea which was similarly held at least by many scientists. This idea in short, was, that the magnetism which accompanied a voltaic current in a wire *A*, should awaken by induction a voltaic current in a wire *B*, placed parallel with it. And we now understand that the reason for the failure of these early experimenters did not proceed from false premises but from the use of crude and insensitive galvanometers. The criterion for success briefly was not some far-seeing grasp of a vague principle, but a mechanism sufficiently powerful to make the phenomenon of induction evident through the crudeness of the then experimental apparatus. Faraday states this to some effect in this "corrective chronological note" written in April, 1832.* "I experimented on this subject several years ago, and have published results.† The following also is an extract from my note-book dated November 28, 1825: 'Experiments on induction by connecting wire of voltaic battery; a battery of four troughs, ten pairs of plates, each arranged side by side—the poles connected by a wire about 4 feet long, parallel to which was another similar wire separated from it only by two thicknesses of paper, the ends of which were attached to a galvanometer—exhibited no action, etc., could not in any way render any induction evident from the connecting wire.' The cause of failure at that time is now evident (April, 1832)."

Faraday's crucial experiments can only be given more

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* Experimental Researches, p. 41.

† *Quarterly Journal of Science*, July, 1825, p. 338.

or less in brief outline, though their elegant logical arrangement in his paper would merit their quotation at length. Among them were:

(1) About a cylinder of wood, some 26 feet of 0·05 inches diameter of copper-wire was wound alternately with twine for insulation. (It is noteworthy that Faraday had not come to the happy idea of insulating the wire as Henry had done). This helix was then covered with calico and a second helix similarly applied, and so on until twelve such coils had been wound. Two separate circuits were formed through these coils by connecting the alternate helices in series. Two wires each of 155 feet were thus coiled so that their electrical circuits were parallel and similarly directed, though we are not informed of the number of turns in the compound helix. One circuit was connected with a galvanometer and the other with a powerful voltaic battery. It is recorded "that not the slightest sensible deflection of the galvanometer could be observed."

(2) "A similar compound helix, consisting of six lengths of copper and six of soft iron-wire was constructed. The resulting iron helix contained 214 feet of wire, and the resulting copper helix 208 feet; but whether the current from the trough was passed through the copper or the iron helix, no effect upon the other could be perceived at the galvanometer." This experiment shows especially how insensitive Faraday's galvanometer must have been, otherwise one cannot understand how he failed of some deflection.

(3) "Two hundred and three feet of copper-wire in one length were coiled around a large block of wood; other 203 feet of similar wire were interposed as a spiral between the turns of the first coil, and metallic contact everywhere was prevented by twine. One of these helices was connected with a galvanometer and the other with a battery of 100 pairs of plates 4 inches square, with double coppers and well charged. When the contact was made, there was a sudden and very slight effect at the galvanometer, and there was also a similar slight effect when the contact with the battery was broken." The partial success in this experiment

seems to have been due to the excessive battery used, which was many times as powerful as that employed in the first test.

After having established this "volta-electric induction," as he calls it, Faraday proceeded to the "evolution of electricity from magnetism."

(4) This experiment is so well known and so similar to that already enlarged upon in connection with the work of Henry that it may be very briefly summarized. "A welded ring was made of soft, round bar iron, $\frac{7}{8}$ of an inch in thickness, and the ring being 6 inches in external diameter." Two compound helices were wound as above on the ring opposite each other in position. "The helix *B* was connected by copper-wires with a galvanometer 3 feet from the ring." The helix *A* was "connected with a battery of ten pairs of plates 4 inches square. . . . The galvanometer was immediately affected, and to a degree far beyond what has been described when with a battery of tenfold power helices *without iron* were used; but though the contact was continued, the effect was not permanent, for the needle soon came to rest in its natural position, as if quite indifferent to the attached electromagnetic arrangement. Upon breaking the contact with the battery, the needle was again powerfully deflected, but in the contrary direction to that induced in the first instance."

A second detail of historical value occurs in the now celebrated paper of Faraday, and it relates to the working conception which he had developed to generalize the phenomena of electromagnetic induction, whereby he had treated the magnetic field as if it were made up of curved lines of force or of "magnetic curves." It is at this point that the work of Faraday becomes closely associated with that of Lenz, and the discussion of these lines of force may preferably be deferred until it is called up by the strictures which Lenz placed upon them.

But just here where the action in the development of the phenomena and laws of electromagnetism and electromagnetic induction pass over from the labors of Faraday and Henry to the investigation of Lenz, it seems not inap-

propriate to quote the impromptu lines of Herbert Mayo, leaving to the reader to decide whether they may not more appropriately be applied to the initial experiment of Henry than to the labors of Faraday which they originally celebrated.

"Around the magnet, Faraday
Conceived voltaic lightnings play ;
  Yet could not draw them from the wire !
He learned a lesson from the heart :
'Tis when we meet, 'tis when we part,
  Breaks forth electric fire ! " *

End of Part I.

Correspondence.

WATER-SUPPLY IN ANCIENT JERUSALEM.

To the Editor:

In Dr. Leffmann's interesting paper on the water-supply in ancient Jerusalem (this volume, pp. 103–107), the translation of the Siloam inscription discovered in 1880, being derived from the French, does not make it clear that the tunnel was begun from the two ends. The translation of the inscription given in Bennett H. Brough's "Treatise on Mine Surveying" (ninth edition, 1902) is as follows: "[Behold] the excavation! Now this is the story of the tunnel: While the miners were still lifting up the pick towards each other, and while there were three cubits [to be broken], the voice of one called to his neighbour, for there was an excess in the rock on the right. They rose up—they struck on the west of the tunnel; the miners each to meet the other pick to pick. And there flowed the waters from their outlet to the pool for 1200 cubits, and [three-quarters] of a cubit was the height of the rocks over the heads of the miners." B. H. B.

LONDON, February 17, 1903.

To the Editor:

In reference to the above letter, I would like to say that I think that the phrase given in my paper ("the borers worked their picks in opposing directions, and there were 3 cubits to break through") indicates that the work was carried out by two gangs working in opposite directions. Regarding the word translated "blind alley," it must be noted that the French text reads "accident," instead of which Dr. Jastrow, who gave me the reference, suggested "cul-de-sac." I adopted the suggestion and translated as above. I incline now to the view that the best reading would be "overlap," indicating that the gangs, not meeting exactly, passed each other for a short distance. Hearing each other through the intervening partition they broke it through.

HENRY LEFFMANN.

PHILADELPHIA, March 20, 1903.

*Altered from Gladstone's Life of Faraday, p. 200.

Notes and Comments.

COOPER HEWITT INTERRUPTER AS AN AID IN WIRELESS TELEGRAPHY.

Each advance in wireless telegraphy has emphasized the inefficiency of the spark-gap interrupter, and this element has threatened to be the weak factor in the commercial development of aerial transmission. In the Marconi trans-atlantic experiments the power required at the disruptive gap was enormous in comparison with the presumable quantity of energy radiated from the antennæ, and a serious incident of the great local disturbance thereby set up has been the adverse effect on telephonic service over a wide range, which forecast trouble for the exploiters of commercial wireless telegraphy. It is, therefore, a matter of unusual interest to learn that an interrupter for an oscillating circuit has recently been devised which not only very greatly reduces the draft on the source of electrical energy but possesses most valuable properties with respect to exact control, and at the same time is extremely simple in form and application.

In wireless telegraphy the spark-gap oscillating circuit has heretofore been employed, either in connection with the simple induction coil or the disruptive gap In his studies on the mercury vapor tube, it occurred to Mr. Peter Cooper Hewitt that the "electric valve" property of the vapor tube, which he has employed in his static converter, could be applied to the oscillating circuit. This application he has succeeded in carrying out in a most successful manner.

Briefly stated, the spark-gap of the oscillating circuit is replaced by a mercury vapor tube in parallel with a condenser. Assuming that the immediate source of electrical energy is a transformer, in the transformer secondary in series are a condenser and the primary of the antennæ-ground circuit, the condenser being shunted by a vapor tube. The tube does not differ in principle from the usual Cooper Hewitt vapor tube, though naturally of a somewhat different form, owing to its different application, and the nature of the work to be performed. The transformer secondary voltage may range between 10,000 and 20,000 volts.

The fundamental advantage of this interrupter is the enormous speed of interruption that may be attained, and the absolute control of this speed. Moreover, by proper design and adjustment, any given rate of adjustment can be secured. With the disruptive spark there is a limit to the efficient rate of interruption fixed by the time required for the condenser to clear itself, and this rate, as well as the total effect, is variable, owing to the mobility of the arc, the condition of the knobs with respect to polish, etc. This latter consideration does not apply to the mercury electrode surface, and the vacuum discharge is not subject to similar fluctuations. It follows that with this new type of interrupter it is possible to create and maintain continuously oscillations of an absolutely definite character, the great importance of which consideration with respect to wireless telegraphy is obvious.

The practical advantages of the interrupter are no less evident. The efficiency is very high, the loss being about proportional to the drop of about

14 volts in the tube, and in a circuit of 10,000 volts this amounts to but a small fraction of 1 per cent. The device, consisting merely of a glass tube or bulb with sealed-in electrodes, is inexpensive, and in case of breakage can be immediately replaced by another in the same manner as an incandescent lamp.—*Electrical World.*

WIRELESS TELEGRAPHY AND THE "ST. LOUIS."

The painful uncertainty attending the belated "St. Louis," of which nothing was heard, from the time she left Cherbourg until she was sighted at Nantucket, a week overdue, suggests that for passenger ships at least, the time will be welcomed when every vessel is equipped with a wireless telegraph outfit. Although none of the vessels so equipped would be capable of repeating Marconi's feat when he communicated from one of the vessels of the American Line over 1,500 miles at sea with the powerful Poldhu station, a range of say 200 miles should be quite within commercial practicability. Considering the crowded condition of the various steamship lanes across the Atlantic, it would be impossible, were all passenger ships so provided, for a vessel to remain unspoken for more than a day or two at the longest; and a liner disabled in mid-Atlantic should be able to communicate from ship to ship with her home port and news of her trouble be made known, long before the day set for her arrival. In this way an enormous amount of anxiety could be spared to relatives and friends on the all-too-frequent occasions when transatlantic vessels are disabled. Indeed, we consider that just as soon as wireless telegraphy has been placed on a thorough commercial basis, it would be quite within reason for a law to be passed requiring all ships to install some one of the wireless telegraph systems which will be on the market.—*Scientific American.*

Book Notices.

The Alaska Frontier. By Thomas Willing Balch, A.B. (Harvard), member of the Philadelphia Bar. Philadelphia: Allen, Lane & Scott; large 8vo, pp. 212.

This book is an exhaustive study of the Alaska boundary question, about which Mr. Balch published a paper, "The Alasko-Canadian Frontier," in the *Journal of the Franklin Institute* for March, 1902. To collect his information Mr. Balch traveled as far west as Alaska and as far east as St. Petersburg. This book gives a complete account up to 1903 of all the facts relating to the boundary question, including the negotiations that preceded the Anglo-Muscovite Treaty of 1825; the subsequent official acts of the various interested Governments, such as the turning back by Russian officials in 1834 of the British brig "Dryad;" the events leading up to the purchase of Alaska by the United States, including a letter on that subject by Frederick W. Seward, the son of Secretary Seward; the International Law governing the case; and reproductions of twenty-eight maps, some of them very rare. The author proves conclusively that up to the present time the Canadians have not advanced in support of their contentions anything but "a nebulous maze of

alleged facts," and their whole argument is founded upon a quibble. He shows that the Canadians do not rebut the evidence afforded by the many Canadian, English, French, German, Russian and other maps which mark the frontier line claimed by the United States, and calls special attention to the fact that in 1901, three years after the Quebec Conference, the English Government supported, through its official geographers, the British Admiralty, the claims of the United States by giving her a continuous lisière above 54° 40′. W.

Calorimetry. By Frank H. Bates. 12mo, ix+127 pp. Philadelphia: Philadelphia Book Company, 1902. (Price, $1.00.)

A practical treatise on the determination of calorific value of fuels in steam-boiler practice. The subject is treated in a readily comprehensible manner. W.

Bricklaying. By Owen B. Maginnis. 8vo, pp.85. New York: Author, N.D. (Price, $2.00.)

This work is a practical treatise on the art of bricklaying, intended for the use of engineers, architects and builders. It gives in concise form and with numerous illustrations the best modern practice of the art, and should be a useful compendium for those having occasion to obtain information on the subject of which it treats. W.

The Slide-Valve and its Functions, with special reference to modern practice in the United States (with ninety diagrams and illustrations.) By Julius Begtrup, M.E. (8vo, vii+143.) New York: D. Van Nostrand Company. London: E. & F. N. Spon, 1902. (Price, $2.00.)

The author has endeavored in this work to explain and illustrate the fundamental principles of valve mechanism by new graphical methods, and describes and analyzes a number of special valve constructions to exhibit how the exacting conditions of higher steam-pressure and higher speed are now met by modern engine builders.

The several chapter-heads read as follows: I. The common slide-valve; II. Improved slide-valves; III. Four-valve systems; IV. Independent cut-off; V. The slide-valve on pumps; VI. Angularity of connecting-rod and eccentric rod. W.

Franklin Institute.

[*Proceedings of the Stated Meeting held Wednesday, March 18, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 18, 1903.

President JOHN BIRKINBINE in the chair.

Present, 121 members and visitors.

Additions to membership since last report, 16.

Mr. A. D. Bramhall, on behalf of the American Brazing Company, of Philadelphia, read a paper describing the process of brazing iron castings, invented

by Herr Pich, a German inventor, and exhibited a number of specimens, large and small, of cast-iron articles that had been repaired by the process. An experimental demonstration of the process was also made.

The subject was freely discussed.

Mr. Frank A. Brunner, of Philadelphia, read a brief communication describing the Keystone Photographic Printing Machine, which was followed by an exhibition of its operation. The source of illumination in this apparatus is an electric arc lamp of special design intended to afford the maximum quantity of the actinic rays, and the object sought to be accomplished is the rapid and economical printing of photographic negatives, whether films or glass, independent of weather conditions.

Adjourned. WM. H. WAHL, *Secretary.*

Committee on Science and the Arts.

[*Abstract of proceedings of the stated meeting held Wednesday, February 4th, and the adjourned meeting Wednesday, February 11, 1903.*]

MR. CHAS. E. RONALDSON in the chair.

Mr. Chas. E. Ronaldson, the newly elected Chairman, assumed the chair. The retiring Chairman, Mr. Thos. P. Conard, was accorded a vote of thanks for his services.

The following reports were adopted:

(No. 2230.) *Speed-Controller.*—Consolidated Machine Specialty Company, Boston, Mass.

ABSTRACT.—The method of obtaining variable speed generally in use is the well-known pair of steep cones with the shifting belt. This method is not at all adapted to present conditions, and machine-tool builders are striving to replace the steep-cone method by something of a more efficient character.

The device here referred to consists of two cast-iron disks, one keyed to the shaft and the other to a quill rotating on this shaft. Two friction-wheels which separate these disks may be rotated by means of a handle around a point which is also the center of the circles formed by the cast-iron disks; a pulley is keyed to this shaft and one to the quill, and the two disks may be forced together by means of a friction-clutch operating through a spiral-spring. A ball-bearing washer reduces the friction due to the thrust, to a minimum.

The operation of the countershaft is extremely simple, the power being delivered to one of the pulleys and taken off at the other, the relative speeds depending upon the position of the friction wheels. These wheels have a rawhide face and run on antifriction bushings made from wood which has been boiled in a composition of paraffin and other ingredients. These wheels do not require any lubrication, and as the bearings are all of the ring-oiler type, but little attention to this detail is required. The pressure on the fric-

tion-disks can be adjusted to any desired amount by means of the friction-clutch.

The report then proceeds to discuss the experimental trials of the device made under the sub-committee's directions, and concludes with the recommendation of the Edward Longstreth Medal of Merit to the inventor of the device, Mr. H. H. Cummings, for the development and introduction of a device called a speed-controller, used in connection with a source of power of constant speed as a means of obtaining variable speed on the driven shaft. [*Sub-Committee.*—Charles Day, Chairman; Lucien E. Picolet.]

(No. 2249.) *Magnetic Clutches.*—Bion I. Arnold, Chicago, Ill.

ABSTRACT.—The system devised by Mr. Arnold has been planned with the view of building direct-connected electric-power plants which should retain the flexibility of operation of the old-style belted plants, with the advantages of direct-connected construction..

By flexibility of operation is meant, that in case of an accident to an engine the generator run by that engine can be run by another engine.

The report proceeds to describe in detail the various applications of the system, which would not be intelligible without the aid of illustrations. The award of the Edward Longstreth Medal of Merit is made to applicant for the originality and skill displayed in the invention. [*Sub-Committee.*—Francis Head, Chairman; Arthur Falkenau, Charles Day.]

(No. 2267.) *Device for Measuring and Recording the Variable Diameter of Tubes.*—L. Bancroft Mellor, Philadelphia.

ABSTRACT.—The object of this device, which is protected by letters-patent granted to applicant, is to disclose the condition of the interior of boiler-tubes as to scale, blisters and other defects which may increase or diminish the normal diameter.

The variation in relative distance between two measuring points of the instrument is recorded on a revolving disk.

The instrument consists of a tube serving as a frame, mounted in which is a tranverse-wheel, which rotates by contact with the inside of the tube to be measured as the instrument is pushed forward for the purpose of exploration.

By suitable gearing, this wheel rotates a disk on which the recording paper is mounted. A movable finger opposite to the traverse-wheel is mounted in the frame. This finger acts in a lever, causing a reciprocating motion of a rod carrying a pencil which rests on the recording paper, the motion of the pencil corresponding to the reciprocating motion of the finger.

Thus the relative distances between the traverse-wheel and the finger are recorded, and the varying diameters of the center through which the instrument passes are approximately recorded in a sinuous line. . . . Diagrams taken from various boiler-tubes were submitted for inspection, and it was stated that by means of this instrument unsuspected defects in boilers have been detected.

The report recommends the award of the John Scott Legacy Medal and Premium to the applicant. [*Sub-Committee.*—A. Falkenau, Chairman; Henry F. Colvin, Charles Day.]

(No. 2269.) *Horizontal Folding-Door.*—Wm. A. Cross, Chicago, Ill.

ABSTRACT.—The invention is secured by U. S. letters-patent to applicant, No. 663,219, December 4, 1900, and its object is to provide a simple, strong

and efficient sectional counterbalanced door for warehouses and other commercial buildings.

The doors are made of wood, the upper half combining wood-framing with wireglass; also admits the doors to be of corrugated iron upon a suitable modern frame. The doors are hinged at their tops to the doorframe by butt-hinges or rod-shaped pintle and formed by an upper and lower section of subsubstantially equal size, hinged together. The counterbalance-weights are secured by cords or chains which pass over overhead pulleys, thence down either side of the door to the guide-block or pintle-pins at lower end of bottom section of the door. Suitable hand-hasps are fastened upon the lower section of the door.

The Investigating Committee finds this door to be unique, being an improvement upon the swingdoor type; its nearest competitor being the "rolling-steel" varieties, to which it is superior in that it does not depend upon the integrity of its curtain, for the entire covering might disappear, and this frame would still work as before.

The report proceeds to enumerate a number of advantages claimed for this invention, all of which appear to be substantiated.

The report recommends the award of the John Scott Legacy Premium and Medal to the inventor. [*Sub-Committee.*—Charles E. Ronaldson, Chairman; H. R. Heyl, Ernest M. White.]

(No. 2264.) *Process of Purifying Water.*—J. M. A. Lacomme and Walter Lander, New York.

(An advisory report.)

Stated Meeting, March 4, 1903. (No. 2253.) *Speed Variator.*—Lodge & Shipley, Cincinnati, O.

Not adapted to be abstracted without illustrations.

The report grants the Edward Longstreth Medal of Merit to the inventor, Wm. Schellenbach, for the development of a device called a speed variator, being a means of obtaining from a source of power of constant speed, variable speed suitable for driving machine-tools and other apparatus where such variation is required. [*Sub-Committee.*—Charles Day, Chairman; Wilfred Lewis, Lucien E. Picolet, Tinius Olsen.]

(No. 2254.) *Apparatus for Cleansing Water Pipes.*—Norman W. Stearns, Roxbury, Mass. Inventor, Vincenzo Bonzagni.

(An advisory report.)

The following reports passed first reading:

(No. 2219.) *Method and Apparatus for Storing and Transporting Acetylene.*—John S. Seymour, New York. Inventors: Claude, Hess & Fouché.

(No. 2260.) *Hylo Incandescent Electric Lamp.*—Phelps Company, Detroit, Mich.

(No. 2266.) *Kodak Developing Machine.*—Eastman Kodak Company, Rochester, N. Y.

W.

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ELECTRICAL SECTION.

Stated Meeting, held Thursday, February 12, 1903.

Notes on Recent Electrical and Scientific Developments Abroad.

BY WILLIAM J. HAMMER,
Consulting Electrical Engineer, New York.

THE VALTELLINA 20,000-VOLT THREE-PHASE RAILWAY IN ITALY.

About two years ago I had the pleasure of visiting the works of Messrs. Ganz & Co., in Budapest, Hungary; and through the courtesy of Director Otto F. Blathy, I was given facilities to study the company's 20,000-volt three-phase system for operating electric railroads.

I shall have the pleasure of presenting for your consideration to-night some lantern slides showing certain of the details of the original experimental plant built at Alte-Ofen Island in the Danube, near Budapest. I shall also supplement the illustrations in the paper by certain slides illustrating the details of the generating plant and railroad

equipment in Northern Italy, which I had the pleasure of visiting last September.

For nearly two years Messrs. Ganz & Co. have been installing this plant, and it was officially started up September 4, 1902; and this firm and the Societa'della Rele Adriatica, for whom the work was carried out, are to be congratulated upon the pluck and perseverance they have shown in

FIG. 1.—Map of system of Valtellina 3-phase 20,000-volt R. R. (power plant at Morbegno).

grappling with the well-nigh insuperable difficulties they have had to contend with, and the very able manner in which they have carried out this stupendous undertaking, which represents the most important and interesting electric railway installation in the world; and it is indeed remarkable that so little attention has been given by engineers, especially in this country, to this important and suc-

cessful effort to establish long-distance electric railroading under steam railroad conditions.

I arrived on the ground early in September, 1902, almost simultaneously with the starting up of the road, and spent some days traveling over the entire line; and, although the Lecco-Colico section was not being electrically operated at the time of my visit, all the rest of the road was; and I can bear testimony to the remarkable success of the operation of the road, which compared very favorably in smoothness and reliability of running, in starting and stopping, etc., with any road I am familiar with, either here or abroad; and I am informed that the company already has under contemplation the equipment of the road from Lecco to Milan in addition to the 72 miles already in operation.

This railway system has until recently been operated by steam, and is known as the Lecco-Sondrio and Chiavanna Line. In *Fig. 1* is shown a map of the line. Enormous difficulties have been met with in the installation of this plant, not so much in the employment of the initial voltage of 20,000 volts, but in dealing with the difficulties of the roadbed, which, as in all Italian roads, is execrable; also by reason of the length of the line, the problems in freight and passenger haulage, the very large number of tunnels the road had to pass through, the high winds and freshets in the mountain streams, and the difficulties in electrically equipping a standard gage road of 72 miles in length during the time that it was being constantly operated as a steam road.

The power-house, of which exterior and interior views are shown in *Figs. 2* and *3*, represents about 7,400 horsepower, with facilities for increasing this when necessary.

The plant itself consists of three 2,000 horse-power Shuckert three-phase alternators of the revolving field type, supplying 20,000 volts at fifteen cycles; these are direct-connected to three turbines supplied from a raceway between 2 and 3 miles in length, sections of which are open cuts through the rock, and other sections being through tunnels. The water is carried to the head stock 90 feet above the station and delivered at the rate of 35 cubic meters per second.

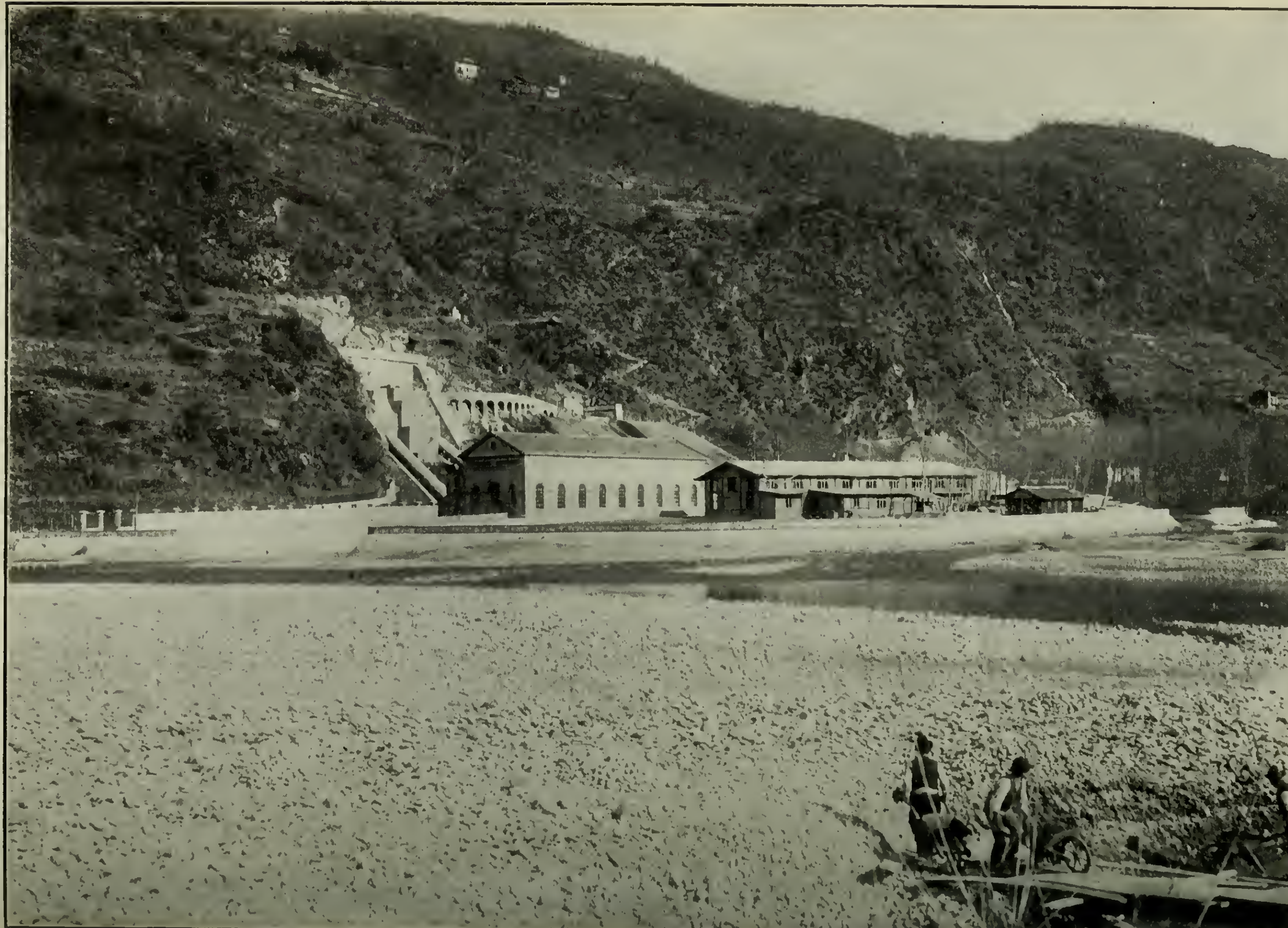

Fig. 2.—Valtellina R. R. water-power plant, at Morbegno.

FIG. 3.—Interior of Morbegno central station.

At the time of my visit but one alternator was being used, and it was claimed that this could be made sufficient to operate the entire road; and the engineers have been surprised to find they would have such a very large reserve of power above all present requirements.

The power-plant is placed at Morbegno, 9½ miles from Colico, or 15½ miles from Sondrio.

The three-phase current of 20,000 volts is connected directly to the primary line, which supplies nine sub-stations equipped with ten 300-kw. Ganz transformers shown in *Fig. 4*, and the necessary switches, arresters and motor-driven ventilating devices for the transformers. At these sub-stations the current is stepped down to 3,000 volts; these stations furnishing current to the eleven independent sections of the overhead trolley line—each about 6 miles in length. Each of these circuits is equipped with fuses. The two overhead trolley wires, each 8 millimeters in diameter, represent two of the phases and the track the third. The line insulators have five petticoats, decreasing in size from top to bottom, and are made of porcelain. The poles are of wood, but eventually will be replaced by steel poles. The line wire, which is of copper, is 7 millimeters in diameter, and was doubly insulated and flexibly suspended.

The high-tension 20,000 feeders were carried over or around all tunnels, some thirty-two in number; but the 3,000-volt trolley wire passed through all tunnels, being supported from the roof at a height of 4 meters 80 centimeters. Especial privileges were accorded by the Government for placing these circuits below the regulation height of 6 meters, where they passed through the tunnels, and it was found necessary to replace the lateral suspension by a longitudinal suspension, owing to strains originally breaking the supporting devices. The increase of speed over that employed in operating the road by steam necessitated the changing of the pitch of the road, and also necessitated altering the trolley circuit to prevent the trolleys striking the tunnel sides. There are seventeen regular stations and eight extra stopping-places. The stations are supplied with incandescent lighting from the railroad power-plant at Morbegno through suitable transformers.

Passenger and freight traffic is operated independently. The types of these cars are shown in the accompanying illustrations, *Figs. 5* and *6*. At the time of my inspection they had ten passenger trains and two freight, and were

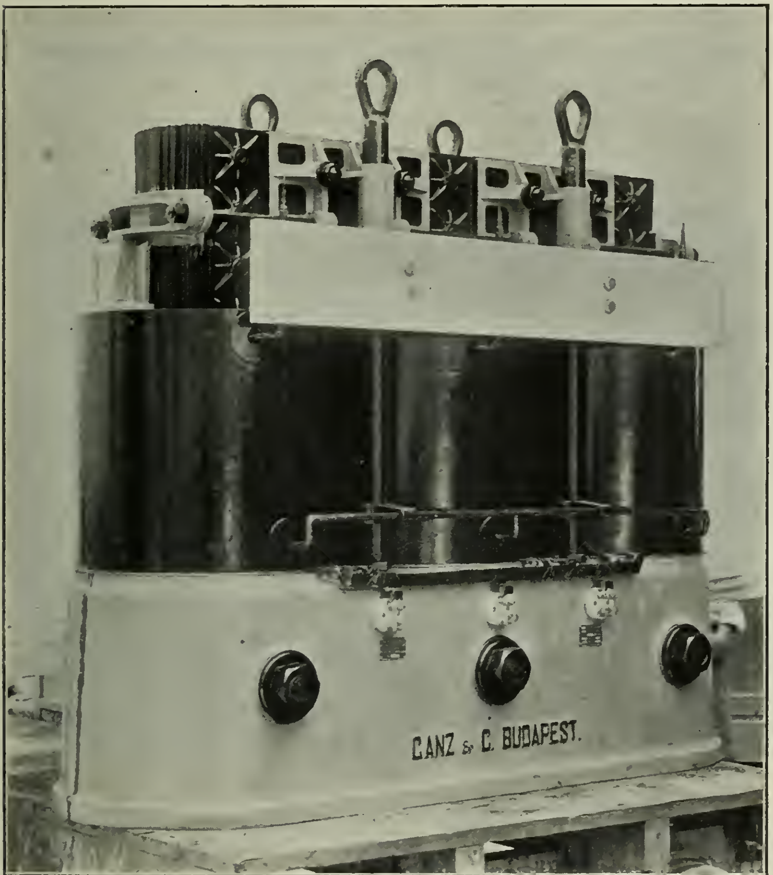

FIG. 4.—300-kw. Ganz transformer, Valtellina R. R.

expecting, in addition, three more passenger and two more freight trains.

The freight locomotives (one of which is shown in *Fig. 6*) are approximately 700 horse-power, employing four motors, and are capable of hauling 500 tons on the level at a speed of 19 miles per hour.

The passenger locomotives are also equipped with four primary motors, operated in parallel, each weighing about $3\frac{1}{2}$ tons, and representing 300 horse-power. A truck equipped with two motors is shown in *Fig. 7*. The schedule speed is about $37\frac{1}{2}$ miles per hour on the level, and about half that on the grade. The cars of the express trains carry fifty passengers, and the local cars each sixty-four passengers.

The trolleys which take the 3,000-volt current direct to the motors consist of two copper rollers, each 16 inches long and having a diameter of $3\frac{1}{4}$ inches. These rollers are

FIG. 5.—Express passenger train, Valtellina 20,000-volt 3-phase R. R.

mounted in the same axial line and have steel ball-bearings. These bearings, however, do not have any current passing through them, it having been found in all trolleys with ball-bearings that the passage of the current through them soon pitted and roughened the surfaces. To the left and right of these pairs of rollers are copper cones about 8 inches long, rigidly attached to the trolley support. The base of the trolley is supported on the top of the car, and has a long horizontal hinge, and the trolley is connected to the piston of an air-cylinder supplied by the air-brake

apparatus on the train, so that the trolley can be readily raised and lowered—a dash-pot preventing jar. The trolleys are plainly shown in *Fig. 6*.

Each of the primary or high-tension motors has its trolley with double rollers. The current is taken from the two rollers by collecting-brushes running in contact with graphite collars, against which they are held by spiral springs. The current is taken from these trolleys by highly insulated wires inside of grounded metallic tubing, 3,000

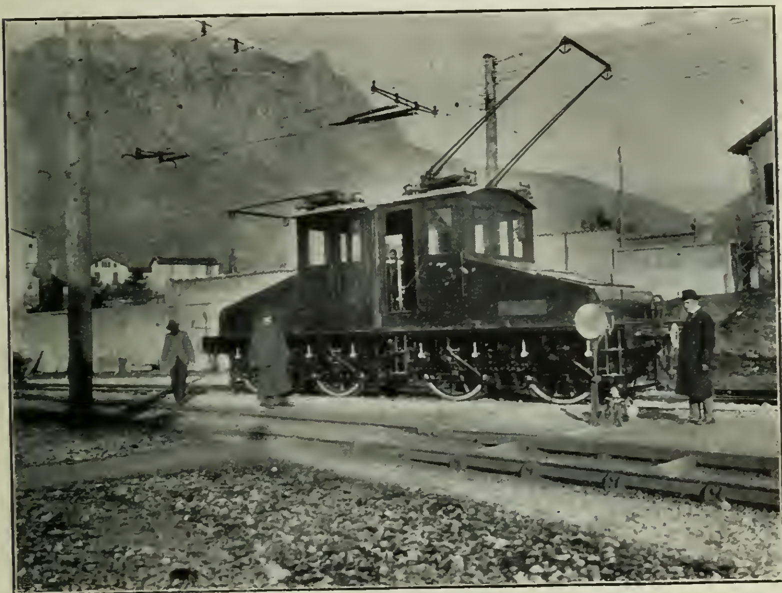

FIG. 6.—Primary or main line switch (3,000-volt).

volts being supplied direct to the motor. Each car is mounted on two four-wheel trucks, one of which is indicated in the appended illustration, *Fig. 7*, and is equipped with two "primary" and two "secondary" induction motors, there being in all four motors of 150 horse-power each.

The rotors each weigh about a ton and a-half. The air-gap is only between 4 and 5 millimeters.

In starting up a train or climbing up a grade the motors are connected in "cascade," or, in other words, while the

3,000-volt current is direct-connected to the stationary windings of the "primary" motors the windings of their "rotors," which are designed for 300 volts, are connected to the stationary windings of the "secondary" motors, while their "rotors" are in turn connected to a fluid resistance. This arrangement gives a speed of about 18½ miles per hour. The controller is thrown to but two positions—*i. e.*, half-speed and full-speed.

When the handle of the controller (shown in *Fig. 8*) is thrown to the second or full-speed position the stationary

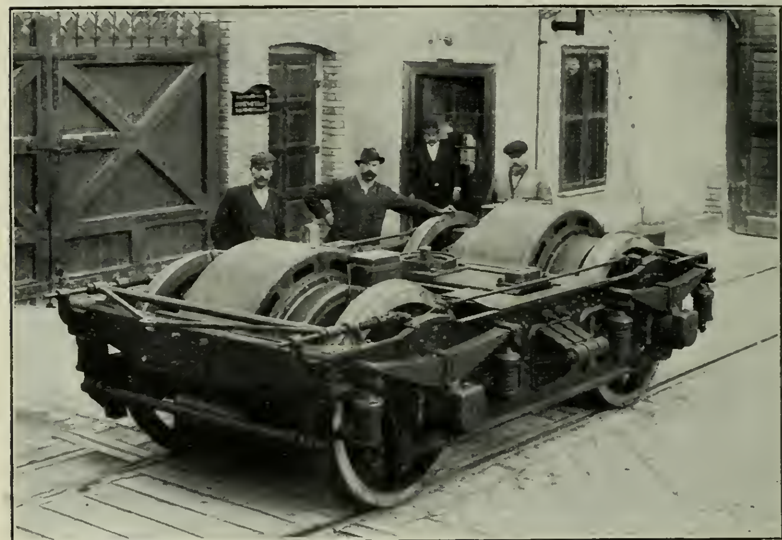

FIG. 7.—Motor car truck, Valtellina R. R., Italy.

fields of the two "primary" motors are then thrown directly on the line, and their rotors are connected to the fluid resistances, which are slowly cut out of the circuit. In the meantime the "secondary" motors have been cut out of the circuit. This full-speed arrangement gives approximately 37½ miles per hour.

The controllers at each end of the car are connected mechanically, and the high-tension switches are connected electrically. A special device renders it impossible for any one to open the boxes containing the high-tension switching

apparatus until a key has been removed from the trolley device; and this key cannot be removed until the trolley has been lowered and the circuit thus opened, rendering it perfectly safe.

A high-tension switch carrying the 3,000-volt primary current is shown in *Fig. 9*, and consists of a horizontal iron

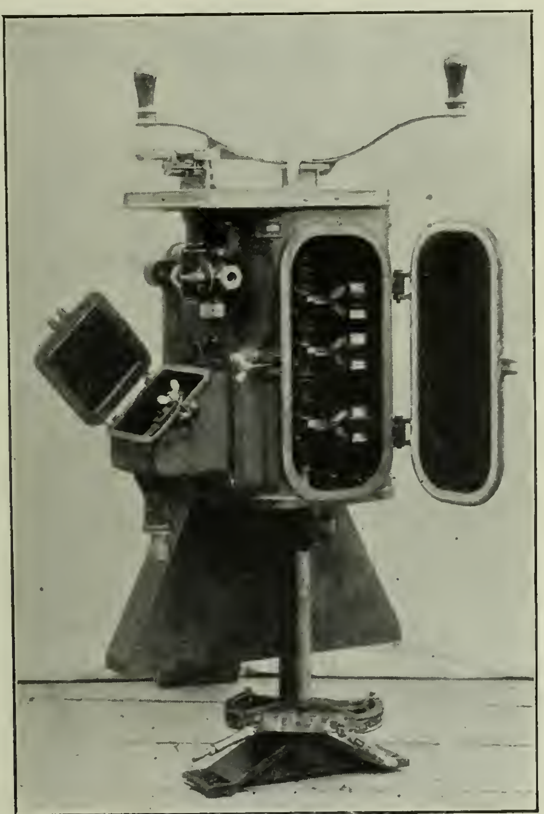

FIG. 8.—Controller, Valtellina 20,000-volt 3-phase R. R.

plate pivoted on a vertical shaft ending in a rack which engages a pinion worked by a crank. The plate is raised by turning the hand crank—this plate having six porcelain-backed bolts with steatite heads mounted on the upper side.

The collecting current circuit is connected to three copper sockets sunk in porcelain insulators, the cables to the three

motors being similarly connected to three sockets. All of the six sockets are directly above the plates which are raised by the crank.

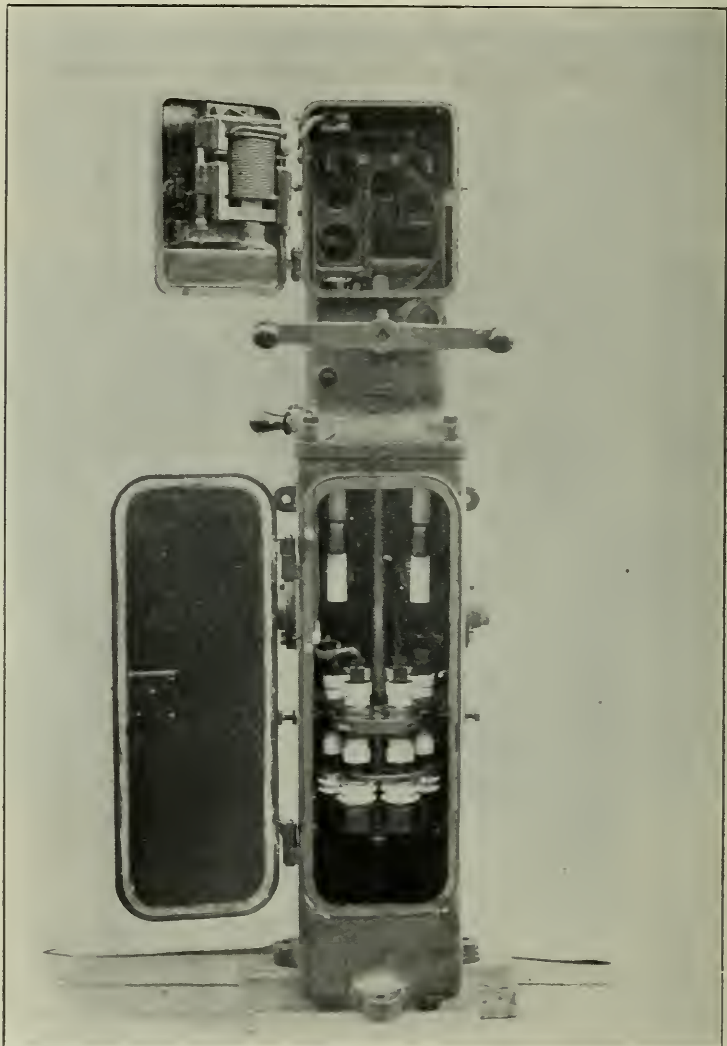

FIG. 9.—Primary or main line switch (3,000-volt.)

The insertion of the bolts into the sockets establishes a perfect connection, and on their withdrawal a rarefication of the air is produced, which to some extent prevents the

formation of an arc, which is further assisted by the steatite heads.

Reversal of the current to the motors may be effected by rotating the lower switch-plate on its vertical axis. A relay placed in the return circuit to the rails causes a cutting off of the current to the motors by lowering the switch-plate should a safe limit be exceeded.

A special device is also provided in case of the potential

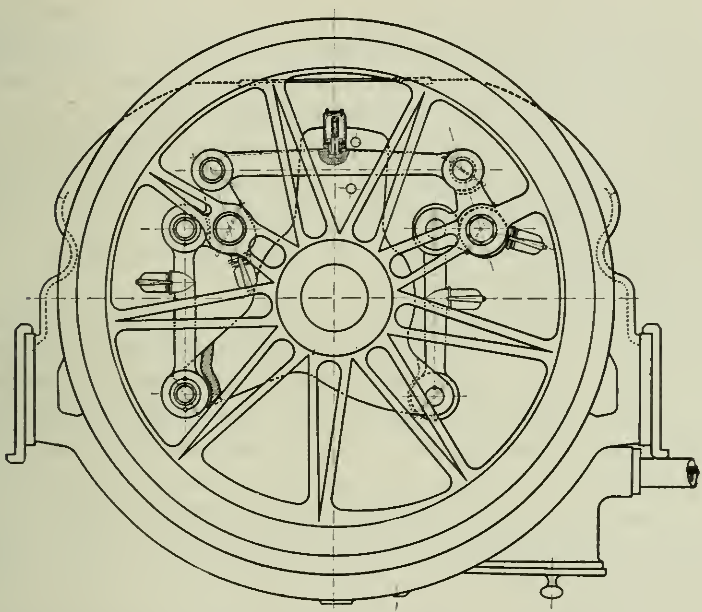

FIG. 10.—Showing flexible coupling for connecting motors to wheels, Valtellina R. R., Italy.

falling, due to a break in the line, by means of which device the 3,000-volt trolley circuit is grounded.

The arrangement employed on this line is such that it is impossible for two trains to move upon the same section of track in the same direction at the same time, as each train leaves the section behind it dead, re-establishing the circuit as soon as it has passed into the next block.

The signaling system employed, when set against an approaching train, at the same time cuts off the current

from that particular section until the train is given the right of way.

The brakes on the train are also automatically applied the moment the train endeavors to enter a section over which the preceding train has the right of way.

During the entire time of operating this road but one accident has occurred, and that was due to a workman forcing the door of the high-tension box open, and thus somewhat severely burning his arm.

The wires of both the field and rotor windings pass longitudinally through insulated tubes in the iron. The ends of the winding are insulated by mica and protected by plates or caps bolted on, and the windings are all invisible.

The motors are direct-connected to the axles. By this I mean no gearing is employed. The axle of the rotor is hollow, the internal diameter being 8 inches and is lined with brass. The car axle, which has a diameter of 4 inches, passes through this hollow axle.

The circuits to the three collecting rings pass through grooves in the rotor shaft, and the rotor shaft and car wheel are flexibly connected, thus preventing jarring and vibrating. The smoothness with which these trains were started and stopped is remarkable. The accompanying illustration (*Fig. 10*) shows the arrangement of this flexible connection.

At one end of the rotor is a driving flange which is connected to the driving wheel on that side of the motor through two links, one of which acts by thrust and the other by tension, the two stresses being of equal magnitude; at the other end of the rotor the three collector-rings, upon which rest the three carbon block brushes supplying current to the rotor.

A 100-volt three-phase motor is supplied with current through an 8-kw. transformer connected to the line and is used for compressing the air for the air-brakes, for raising and lowering the fluid in the resistance boxes, and for raising and lowering the trolleys and automatically operating the high-tension switches.

A circuit from the same transformer supplies current for lighting the train. It was found that the low periodicity of

15 per second caused such noticeable fluctuation in the light of the ordinary incandescent lamp, that three-phase or three-filament lamps were made by both the Cruto and Ganz Companies for this purpose, and are being very successfully employed. I saw lamps of both of these types tested on the circuit, and the three-phase lamps were remarkably steady, while the others were not. I have samples of these three-phase lamps here for your consideration, which I shall describe later.

The liquid rheostat employed on these cars is very ingenious, and has given very satisfactory service. It is a three-phase rheostat, and consists of an iron box with three wings to it, from the top of which depend three separate cylinders. Inside of each cylinder are two sets of iron plates which are rounded at the lower extremity, and vary in length. The alternate plates are connected in pairs, the current entering by one plate and leaving by the other; the sets being attached to the three phases of the low-tension roller circuits, which have a potential of only 300 volts. A cooling device is attached to these rheostats.

The solution employed is sodium carbonate contained in the lower portion of the outer case. The upper portion of this outer case is supplied with compressed air, which, on being supplied to the case, in a greater or less degree, allows the solution to rise in the three cylinders. In rising, the liquid comes in contact with the iron plates, one after another, thus cutting the resistance out of the circuit to a greater or less degree, dependent upon the height of the solution.

This plan, it will be readily seen, is much simpler and far preferable to the raising of the plates out of the liquid.

The device is the result of extensive experimentation, and permits the motor-driving torque to be kept constant during acceleration. The entire height through which the solution passes is less than a foot.

The exhaust valve is the lift type of valve, normally kept open by a spiral spring, and the valve for operating the rheostat is compound-wound, having several openings through it. On being operated the compound valve

first opens a clear way for the compressed air to the cylinder and to the top of the piston, which compresses the spiral spring of the exhaust valve already referred to, and closes this exhaust valve. The air then slowly passes through a small throttled aperture, admitting the air to the outside of the resistance box casing at a low pressure.

When half speed has been attained, the motion of the trolley lever when thrown to full speed causes the air-cock to close the throttling aperture, opening another aperture, and thus relieving the air above the upper surface of the exhaust valve piston, permitting the compression spring of this valve to instantly open, it thus throwing in instantly the whole resistance.

The operations described are repeated in securing acceleration from half to full speed, and in securing retardation from full to half speed, at which time the motors operate in "cascade," as already described.

The Arcioni three-phase recording wattmeter, manufactured by Camillo Olivetti, of Ivrea, Italy, is employed to register the entire output of the Morbegno plant. This wattmeter, I found, is being used extensively in various high-tension plants throughout Europe and is giving very great satisfaction. I know of no instrument for this class of work which has given as satisfactory results. No oil switches are employed in this plant, ropes being used to pull the levers attached to the high-tension switches overhead; and to these are attached Siemen's horned lightning-arresters.

I was informed that no lightning has ever entered the station, and the protection is doubtless due to the very interesting lightning-arrester. Three jets of water are thrown into the air, each jet coming within a short distance of a tap taken from one of the three-phase lines of the high-tension circuit. Any lightning disturbance passing over the line will jump across the intervening air-space, and pass through the water to the ground. The device is most simple, and thus far has proved very effective.

In preparing the data on this most interesting engineering development, I am very much indebted to Director Otto F.

Blathy and Mr. Kando, chief engineer, to whom the success of this system is largely due, and to Mr. Lello Pontecorvo, one of the engineers of the Ganz Company, in charge of the work, who very courteously took me over the road, through the power-house, etc., and furnished me with many of the engineering details. The illustrations and lantern slides which I have presented are from photographs made by myself, and from photographs and drawings furnished me by the Ganz Company.

THREE-PHASE CRUTO AND GANZ LAMPS. OSMIUM AND NERNST LAMPS.

I wish now to present for your consideration several of the most recent European developments in incandescent lighting. These comprise the three-phase lamps of Messrs. Ganz & Co., of Budapest, Hungary, and the Cruto Company, of Italy, such as are used on the Valtellina Railroad, two samples of the Osmium lamp and samples of the latest types of Nernst lamps from Germany and France.

Each of the three-phase lamps are of 16 candle-power, intended to operate on a three-phase circuit of 15 cycles at 110 volts. The filaments employed in these lamps are of carbon, but some lamps have been recently designed on the three-phase principle employing Nernst glowers. One of the lamps closely resembles the ordinary Edison lamp with a screw butt, and protruding from the center of the usual button at the bottom, and insulated from it, is a split pin forming the third connection. The other lamp has a brass collar with three pins protruding at equally distant points, intended to lock in a bayonet catch in the socket. At the bottom of the base, which is of insulating material, are three round contact points, which, by their relative positions, form a triangle. These points are adapted to make a rubbing contact on three corresponding contacts in the socket.

The Osmium lamps are the shape of an elongated egg. They have butts similar to the Edison lamp and porcelain insulation. The filament is anchored to the side of the globe by a glass projection terminating in a spiral of a sin-

gle turn made of material similar to that employed in the Welsbach mantle (which, as is known, is composed of thoria and ceria), this substance taking the place of the platinum wire usually employed in anchored filament lamps. These Osmium lamps are coming into use to a very limited extent abroad, especially in Germany. It is the invention of Dr. Auer von Welsbach, and the invention is controlled both abroad and in this country by the Welsbach interests. It is claimed that so long as the filament remains intact it may be renewed several times. The filament is light gray in color, and in the single filament form, unless anchored to the side of the globe, it is impossible to burn it except in an upright or pendent position (preferably the latter), as the filament, which is very long, is so flexible that it curls over against the glass. The lamps show a very high efficiency, and they have done very well in the life tests.

In a test referred to by Scholz, an Osmium lamp, after burning 1,500 hours, was still intact, and had fallen off in candle-power but 12 per cent., its efficiency in starting being 1·45 watts per candle-power, and at the end of 1,500 hours it showed an efficiency of 1·7 watts per candle-power. The present range of voltage of the Osmium lamp is from 25 to 50 volts. A number of filaments can, however, be connected in series or in multiple series for higher potentials; a few lamps have been made with two filaments in series.

It is to be remembered that Mr. Edison and other inventors many years ago endeavored to manufacture filaments for the incandescent lamp by incorporating carbon and metallic oxides or rare earths and finely divided particles of metal; but experiments in this line have thus far met with but little success.

Osmium, from the Greek osme (smell), so named from the strong, disagreeable odor given out by its oxide, is a blue-white metallic element, and well-nigh infusible. It was discovered in 1803 by Tennant, and was for a considerable time known only as crystalline, grain-like material; and when fused in the electric arc, as a hard brittle substance unfit to be worked. It is secured in the refining of native platinum and from iridosmine. It has an atomic weight of 190·8.

Among the difficulties to be met with in manufacturing and exploiting the Osmium lamp on a considerable scale are the great rarity of the material used in its manufacture and the very low voltage of the lamp, which necessitates the placing of several filaments in series where the direct current is used. Certain tests which have been published abroad show a saving of 60 per cent. as claimed by the Osmium lamp over the carbon lamp, this test being made on four 25-volt Osmium lamps in series in competition with four 100-volt carbon filament lamps in parallel; the Osmium lamp showing a consumption of ·96 amperes and the carbon filaments 2·40 amperes. Recently some results have been published by Remane of tests upon an installation of 300 Osmium lamps made in Berlin, covering a period of ten months. These tests show a very slight diminution in candle-power when operated upon an alternating circuit of 30 volts, and show the consumption of energy to be 1·5 watts per candle, which is 50 per cent. higher than the 3-watt carbon lamps extensively employed. The cost of these lamps is 4¾ marks each, or a little over $1.

The Nernst lamps shown are of two types, the small French lamp being of the alternating type, and it is practically identical with the standard type of lamp manufactured in Germany, with which you are doubtless already familiar, and which I have quite fully described in a paper which I gave before the American Institute of Electrical Engineers, February 28, 1901, entitled "Important European Electrical and Engineering Developments at the Close of the Nineteenth Century."

The large lamp is of the direct-current type intended to operate from 65 to 135 candle-power to fill an intermediary position between the incandescent and arc lamps. The heating coil is a conical spiral which is in a perpendicular position when the lamp is pendent, and the "glower" is in the center of this heating coil. The iron ballast wire is mounted as in the tiny incandescent lamp globe, which is filled with hydrogen gas to prevent oxidation, and screws into the base of the socket. The replacement piece is so arranged that it is impossible to reverse the connections in

attaching it to its support, and the plugs on the socket itself are marked plus or minus, and are not interchangeable. As is well known, it is absolutely imperative to send the current through these direct-current types of lamps always in the same direction; and even then the life of the direct-current lamps is exceedingly low, seldom exceeding 300 hours, and with probably a maximum of 400 hours, whereas the alternating-current lamp can be readily made to give a very satisfactory life.

I have been surprised in visiting the ten countries in Europe which I set foot in during the past summer to find such a dearth of Nernst lamps. Even in Berlin, the home of the parent Nernst Company, I found places where the Nernst lamp was in use two years ago where there was not a single Nernst lamp, and there were few of them to be found anywhere; and in the important expositions which I visited at Dusseldorf, in Germany, and Wolverhampton, in England, there was not a single Nernst lamp in operation.

From what I have seen of the foreign types and the American types of Nernst lamps I am led to believe that the most commercial type of Nernst lamp that is being made to-day is that of the American Nernst Company, which has up to the present wisely confined its energies to producing one single commercial type of lamp, whereas the foreigners have been endeavoring to manufacture and exploit lamps for both direct and alternating currents and a great variety of types, each of which has introduced enormous manufacturing difficulties.

[*To be concluded.*]

DETERIORATION OF LEATHER.

A very striking instance of the deterioration of leather produced under conditions demanding quicker tanning by the use of various chemicals, thus decreasing the durability of the material, is afforded by the fact that the British Museum expends $20,000 a year in rebinding books in leather. Modern leather is entirely different from the material produced by what is now regarded as an effete process, its life being limited to fifteen years. In the search for cheaper and quicker processes of making leather, large quantities of sulphuric acid are used, and this substance, in combination with others, causes the material to decompose rapidly in the course of a few years.—*Scientific American.*

The Forest Policy of Pennsylvania.*

BY GEORGE H. WIRT,
State Forester.

MR. CHAIRMAN, LADIES AND GENTLEMEN:—Dr. William Schlich, the noted English forester, says that the task with which forestry has to deal is to ascertain the principles according to which forests shall be managed and to apply these principles to the treatment of forests. Dr. C. A. Schenck, of Biltmore, North Carolina, gives a very terse definition of forestry and one that is broader than most others. It is: "Forestry is the proper handling of forest investments." He takes into consideration the facts, first, that forest land and forests themselves shall be dealt with as any other investment, namely, that there shall be a yearly return of some kind; and second, that a forest investment may be for some other purpose, primarily, than for yielding a return in wood alone, which indeed may not be considered at all.

From a private standpoint, no matter what the immediate purpose in the management of forests, the ultimate one is usually of a pecuniary nature; yet, under existing conditions, there are many reasons why forestry is not a profitable investment for an individual. Unlike stock, which can be put upon exchange at any time and sold for its market value, a forest cannot be sold at the owner's will. A favorable time must be awaited or, in case of a forced sale, a great loss is usually sustained. Even under very favorable circumstances a forest investment will yield a small rate of interest in comparison with many other projects where money is needed. The present system of taxation, too, takes from the forest-owner not only the profits of his forest each year, but in many cases, if the tax is computed at compound interest

* A lecture delivered before the Franklin Institute and the Central Branch of the Y. M. C. A. in Association Hall, Friday, January 23, 1903.

for a less number of years than it takes a forest to mature, the amount is far more than the original investment, together with what could be obtained from the mature wood and the land. Add to these adverse conditions the uncertainty in regard to partial or total destruction by forest fires, and we can excuse any one for not practising conservative lumbering.

On the other hand, because of certain economic influences of the forests, the State, which is long-lived, can afford to practise forestry and receive a small rate of interest, or even none at all, for some time. One of the first duties of any State is to provide for its own welfare and for the continuity of its life. It has been proved beyond a doubt that forests do influence local climates and water-flow, making possible successful agriculture and fruit-growing, and to any State the agricultural interests are well worth caring for. In few of our Eastern States is the capital and labor employed in the harvesting and the final manufacture of wood less important than that of agriculture. The preservation of such an industry will surely be of advantage to a State.

Moreover, if the State practises forestry on its own land, private individuals will be very apt to pay more attention to their wood-lots and forests; and at the same time, if the State regulates a sufficient area of forests to supply the indirect influences desired, private holdings can, to a great extent, be disregarded. In America, disregard very often is better relished than that which is thought to be an encroachment upon a freeman's rights.

The attitude which any State takes with regard to its forests, however, will be influenced by one or all of four conditions, namely, by the requirements of the country as determined by the number and the culture of its people; by the nature of the proprietorship of the forests; by the existing area of forests, or by the amount of waste land within the State.

In a thinly settled country there is no need of caring for the forests, because the people have few wants and they are easily supplied without disturbing to any great extent the character or area of the forests. As the population and the

desires increase, however, not only the forest is disregarded, but even the rights of neighbors or the good of the community may be lost sight of. Finally, it is the culture, toward which the forests have so largely contributed, that in turn demands the protection and the management of forests at the hands of the State. If it is true that the culture of a people is shown by the condition of the roads, it is equally true that it is shown by the protection afforded to the forests and the management demanded for them by the State.

In the case of a country where the forests are owned by private individuals, or by companies, the attitude of the State toward the forests will depend very largely upon the character of these owners. They may be men who have vast interests at stake and have already recognized the fact that their forests, with some extra care, can be made to yield them a revenue indefinitely. The interests of the community are injured in no way by a suitable forest area, but rather bettered, consequently the State should give ample protection from fires and should regulate taxes so that this condition may be continued. But it is more likely to be the case that these private holders are men who desire a large revenue immediately from their forests, and clear them from high mountains and steep hillsides without regard to a future growth. The results are a rapid run-off of rainfall and melting snow, causing floods and the erosion of the soil.

In many cases these two results may entirely prevent the continuance of profitable agriculture in the neighboring valley. The value of the land rapidly decreases and at the same time the possibility of its becoming valuable again is lessened. Such a condition of affairs is detrimental to the State. One of two things must be done. If protection is already afforded by existing conditions, laws must be passed restricting the rights of individuals on their own land so far as these rights interfere with the rights of others and the welfare of the community, or the State itself must take hold of the forests, or a part of them, and care for them. Where forests are owned and properly cared for both by

individuals and by the State, the latter must come in conflict with its citizens as little as possible.

In a country like Maine, a considerable part of which is wooded, the wealth of the State depends to a very great extent upon the forests. From the time it was first settled the lumber industry has been a predominant one; but gradually it has declined from what it once was, though still of vast importance because of the spruce which is so important in the manufacture of wood-pulp. At the present time, because of the tremendous water-power available, the manufacturing interests have become greater, but their stability depends indirectly upon the forest, nature's water-reservoir. Maine certainly has enough land under forest cover, or what may be called forest land, and her policy must be such as will be necessary for the maintenance of existing forests.

In the prairie States, agriculture and stock-raising are the important industries, but many times neither is possible without great loss because of the wind-storms which frequently pass over the country. There the policy of the State would be that of increasing the forest area. Premiums might be given for plantations, plants raised and distributed—anything in fact that would be an inducement for the people to plant trees, until the advantages could be appreciated, and then the work would go on without State aid. In Nebraska this work has been successfully commenced, owing to the impetus given by the late Hon. J. Sterling Morton.

Again, if the country is in such a condition that each acre of land is yielding its maximum return, that condition is an ideal one and the Government need not concern itself with inducements for changes in management or for a more intense culture. This ideal condition is seldom found; the reverse is common enough. Thousands of acres in this country are not only producing no revenue, but actually causing a loss to their owners and to the Government. In the economy of nature, trees have been made to grow where no cereal or textile crops can be produced, and to improve the soil by their being on it. Forestry does not ask for soil that can be used for more profitable purposes, but it does

ask for, and should by all means have, the land that is fit for nothing but tree-growth. Very often waste land is the result of some policy of the Government. It may be lavishness or it may be exaction. Land may be too easily had to care for old land when the fertility begins to fail or the burdens of taxation and risks from fire may be too heavy. Either case produces the same result. It is to the advantage of the Government that each acre of land should yield its maximum return, and its policy must be such as to bring about such a return as early as possible.

The policy of our own State, "Penn's woods," in relation to its forests, both in the past and what it should be in the future, must be of interest to every citizen.

William Penn recognized to some extent the value of the forests in his Province; for in an instrument dated July 11, 1681, and intended as a Charter of Rights to the colonists, Section xviii reads thus: "That in clearing the ground, care be taken to leave one acre of trees for every five acres cleared; especially to preserve oak and mulberries for silk and shipping." This implied not merely that $\frac{1}{6}$ part of the Province should be left in woodland, but that this woodland should be cared for as a source of profit both to the citizens and to the Government.

After two centuries of disregard for the far-seeing policy of Penn, a few of our public-spirited men were brought face to face with the fact that a great change was taking place within the State by reason of the rapid and unnecessary destruction of the forests. These men devoted themselves to the task of remedying, if possible, the adverse conditions already existing, and of protecting the State in the future from worse conditions that were sure to follow the reckless and wasteful methods of lumbering then going on. Exact data were collected, as well as numerous photographs from all over the State. Then began in earnest the forestry propaganda. First of all the people had to be educated and brought to realize the meaning and the need of forestry. Difficulties were not wanting, but with each new discouragement the men most interested in the State's welfare set forward with a more determined heart. A review of what

has been accomplished in less than a quarter-century will show how well the work has been done.

Previous to 1880 there were several laws upon the statute books, the import of which was "to prevent the burning of the woods" and to bring to justice persons guilty of such offense. The penalty varied from $50 to $500. That they were ever enforced we have no knowledge, but they served at least one purpose—a precedent.

In 1886, the Pennsylvania Forestry Association was founded and has been a growing power. The next year an act "for the encouragement of forest culture," by a rebate of taxes on land planted up with forest trees, was approved. This law recognized one step in advance of anything that had gone before, namely, the benefit of forests to a community and that the community should pay for its benefits.

In 1893, a Forestry Commission, consisting of a botanist and a civil engineer, was created. The commission made its report to the Legislature in 1895, which was printed as Part II of the Report of the Department of Agriculture. It was widely circulated and has done more, perhaps, toward forming a popular interest in forestry in this State than any other publication. In that same year, when the Department of Agriculture was created, a Division of Forestry was provided for and a Commissioner of Forestry appointed.

Two years later, in 1897, Governor Hastings approved an act "authorizing the purchase by the Commonwealth of unseated lands sold for the non-payment of taxes, for the purpose of creating a State Forest Reservation." This was the foundation of the present reservation system of the State. In 1899 this act was amended by authorizing the Commissioner of Forestry, under certain provisions, to purchase unseated lands other than those offered at tax sales.

In 1897, other laws, making constables of townships ex-officio fire-wardens, providing for the expense of suppressing fires, to be borne equally by the State and county, and for the punishment of offenders, were approved. A special act was also passed to secure State Forest Reservations at the head-waters of our three principal rivers. These laws

placed forestry on a sure footing and gave it an impetus that cannot be halted.

The importance of the work so impressed Governor Stone and the Legislature that in February, 1901, the Division of Forestry was raised to a department, with the Commissioner of Forestry as chief of the department, and at the same time President of the Forestry Reservation Commission. The powers of the Commissioner were increased, and to-day, because of the whole-hearted and efficient work of the present Commissioner, who has held the appointment since the creation of the office, our State stands in the lead of those taking up forestry work, and it is possible to say that, as whole, the people of our Commonwealth have nothing but good words for the forestry movement. The success which has come is due, no doubt, not from asking the public to accept an ideal at once, but from starting on the right road and gradually, step by step, leading up to the position desired.

Now, the policy of the future. First of all, it shall be, as it has been, practical. Forestry is a business, and the preservation and perpetuation of our forests must be done on a practical business basis, not on any æsthetic or sentimental basis. Of the utmost importance is the continued education of the people. Notwithstanding the work done in the past, traveling through the country one frequently meets people with very queer ideas in regard to the forests and to the meaning of forestry. Such people are the ones who must be reached. But they are not the only ones. The people of the cities and the larger towns, too, are not as well acquainted with the principles of forestry as they should be. There are two ways by which this condition can be changed.

The Governor issues a proclamation each year naming two spring days for the planting of trees and shrubbery by the citizens of the State, and the Superintendent of Public Instruction, in accordance with the Governor's proclamation, urges the observation of the day in the public schools. Whether the day is observed by a school lies usually with the teacher, and it is a question whether one-tenth of the schools do observe it. The importance of spreading the

interest in Arbor Day is that through it the children can be reached. If a child can be induced to help plant a tree, and watch it grow, or, better still, to plant a seed and await its development, that child will learn to love the tree and to look upon it as a friend. A very few words in connection with such an exercise would teach the child the use of the forest and the value of trees. Arbor Day, then, might be made a necessary part of the school-work, or if that is too radical, at least the Department of Public Instruction, or the Department of Forestry, or the two working together, might publish an annual bulletin containing appropriate matter for various programmes, getting it up in an attractive form, to be distributed to the teachers all over the State. Other States do this, and very good results have been accomplished. If the children of to-day appreciate the forests, the forests in the future are safe. The Superintendent of Public Instruction also names an autumn Arbor Day, to be especially observed by the public schools of the State.

Arbor Day, when made popular, will necessarily reach a number of the older people, but they must be presented with graver problems and shown how these are to be solved. There is no better opportunity at present for this than making use of the farmers' institutes. This is an open field and should be filled at once. Some phase of forestry should be made a part of each programme. Arrangements can be made for this field through the Department of Agriculture.

One of the greatest questions which the State has to meet in this connection is the utilization of the large amount of land, at present valueless, which is classed as agricultural land, and which is, as a matter of fact, an expense to the owner instead of a profit. The time is here when our farmers must practise more intense farming, concentrate their energy upon the best of their land and allow the remainder to regain its fertility by reforestation. Pennsylvania may be claimed as one of the greatest agricultural States in the Union, and yet a good authority estimates the waste land attached to its farms at about 4,000,000 acres. This land

must not continue longer as a menace, but must be, as it were, redeemed to the people. It would be impossible for the State itself to care for such areas, consequently the policy must be toward helping the private owners to do the work. Already a reduction in taxes is offered for plantations, but this is not sufficient. Some system, such as Canada has, will bring about quicker and better results in connection with the rebate. Personal attention is offered each farmer as he applies for aid, a forester giving instruction as to the preparation of the soil, the species to plant and the method of planting. The farmers could raise their own seedlings, or better still, they could be raised in the nurseries on the reservations and distributed at a nominal cost. Free distribution would lead to wastefulness, and distribution without instruction in most cases will amount to failure.

Beside this large amount of waste agricultural land, there are about as many acres of so-called forests which are practically waste in their present condition. Much of this is in such a shape that it can be held only by private people. The value of a wood-lot on a farm is generally recognized; but many people, from gross ignorance of the requirements of tree-growth, have managed their wood-lots in such a way that little more than firewood can be obtained from them. From instruction at Institutes the farmer can adopt a better system of management and in a few years have an improved forest. However, the owner must be helped in other ways. A wood-lot is of advantage to more than its owner, consequently the taxes should be shared with the township or county. This is already provided for in a way; but just at a time when the trees are growing most the full tax is lifted and the owner must cut his timber to make his profit. The rate of taxation on forests ought to be very low, or some basis should be established whereby only the value produced each year is assessed.

In addition, the existing fire laws must be vigorously enforced to protect the property upon which taxes are paid. Offenders must be brought to justice and punished with a fine corresponding to the crime. Objections have been raised to the fire laws as they now stand, but they are the

best that could be obtained at the time. If an advance can now be made, the present Legislature will make it. One improvement would be the appointment of a chief Fire Warden, with a number of sub-wardens, all under the direction of the Commissioner of Forestry, whose duties shall be to keep a lookout for fires, see that the ex-officio fire wardens do their duty, and to act as detectives when fires occur. It is cheaper to prevent fires than to pay for putting them out and to bear the loss they cause. In a larger sense must this protection be given to owners of extended forest areas, and wherever desired or possible the State forest officials should aid private parties with the management of their forest land.

Pennsylvania has recognized both sides of the forestry question—private and governmental. Her policy has been to aid in making private forestry not only possible but profitable, and at the same time she has felt that the forests at the head-waters of the principal streams should be managed, not by any system that would change with the whim or necessity of an individual, but by a system of forest management which has the greatest good to the greatest number in view at all times.

In 1898, the Commissioner of Forestry purchased some land at tax sales, but this was allowed two years in which to be redeemed. In March, of 1900, the first land actually passed into the possession of the State. Since then the reservations have gradually increased until, at present, land is owned in twenty-two different counties. In less than two years the State has actually paid for over 400,000 acres of land and the Reservation Commission has almost as much more under consideration. Not an acre has been bought without a previous examination to determine the character of the timber and the location of the land. The owners first make an offer of the land to the Commission. It is then examined and an estimate of its value for reservation purposes placed upon it. If the commission accepts the land on this report, and the price is satisfactory to both parties, it passes into the hands of an experienced title examiner. If the title is clear, the land is deeded to the Commonwealth and paid for at once. When any defect in a title is found,

it must be satisfied before the Commission will accept a deed, consequently there will be no fear of future trouble arising from imperfect titles. So far, it has not been necessary for the Commission to ask for lands, nor has it been necessary to use the right of eminent domain. It is to be hoped that the latter never will be resorted to, but the purchase should continue until at least 2,000,000 acres can be claimed as forest-producing recreation grounds for our people. When that amount has been obtained, conditions may demand that more be managed by the State.

The management itself of these various reservations is the most interesting question facing the Reservation Commission. However, it seems that there ought to be very little difficulty in this direction. There are no laws which hamper in any way the necessary progress. The greatest need is trained men who can carry the work forward. Of course, any work implies a sufficient appropriation, and this should not be slight, for it must be understood that the money paid out for these lands and for their care is not an expense. It is an investment, and a good one, for the State. Some have said it is a "grab" upon the treasury, but it is no more a grab than is the legitimate and necessary appropriation to the public schools, for the forestry management will result, not only in a money return to the treasury, but in a continued industry of the State, purer water for our cities and better health for our citizens.

As long as the State continues its purchase of land the present reserves will be changing their boundaries more or less, but this cannot alter the fact that what has been purchased already must be cared for. Better not have it than not care for it. The first step toward the protection of the reserves must be the survey of the boundaries. It settles at once and forever the ownership of the land and sets the bounds within which the reservation officers are expected to know every detail. The mere boundaries, however, are not enough for a forester. He should have what is called a "forest survey." Upon it he bases his plans for a given period in the future. Primarily he must know the amount of wood at his disposal, its position, its kind, its quality, its

age, and so forth. To plan for the marketing of the produce at the least cost a topographical map should be available, showing contours, streams, roads and trails, and for other purposes the clearings, houses and all points of interest should be marked.

Like other arts, forestry has an ideal toward which all efforts trend. It is what is known as the "normal growing stock" and the "normal annual increment." The normal growing stock is the largest amount of desirable wood that can stand on a given area, being in such proportion as to age gradations that an equal amount of wood is matured each year, which equals the normal increment. While this ideal can never be reached, yet it is important that the condition of the forest be brought as near to it as possible, for not until then will the forest produce its largest revenue. In other words, we may consider part of the forest as capital and part as interest. There may be too much capital invested to yield the highest returns. In that case some of the capital in the shape of trees must be taken out. There may be too little capital invested, consequently it must be increased as rapidly as possible. The latter is the condition of most of our reserves, and the longer we delay in bringing the capital of the forest to its proper level, the more money is lost to the State in the future.

One of the best ways to increase the value of the forest is to make good, serviceable roads. The roads of this country are notorious for their lack of any good qualities, and yet enough money has been spent upon them to make their dust as valuable as gold. Fortunately, the good-roads movement is gradually gaining force and every patron of forestry must be a patron of it. There are many instances in Germany where profitable forestry could be practiced only after the building of a road through the district. The same thing is and will be true in our State.

Within the reservations the Department of Forestry should have entire control of all roads, at least so far as is necessary to build a complete system of serviceable roads and trails upon each reservation. Where changes in the present roads are desirable, the department should be at

perfect liberty to make such changes. Already a slight provision has been made along this line. Of course the State pays no taxes on its land. To compensate the township, $25 for each mile of public road within the reservation in that township is allowed to be expended by the Department of Forestry for repairs. Thus far the expenditure, where made, has been of very great value. In two years one road in Pike County has been transformed from a rough and muddy road to a smooth and well-drained one, requiring but a small sum now each year for its repair. When once the roads are made in proper shape, money is saved in the repair account forever afterward. Each reservation must have its own system of management, necessarily its own system of roads and trails.

The value of good roads for transportation and for making a forest accessible is obvious. However, they serve other purposes as well. It is necessary in all forests to have fire-lanes. Some authorities advocate the policy of cutting broad strips at certain distances through the forest, and of keeping these strips clear of debris of all kinds. Such policy is not a good one from our standpoint. The land so used is kept unproductive and is an expense each year. There are two ways in which a fire-lane is of use—a line from which to start a back-fire and a line at which a side-fire will stop for lack of fuel. A 2-foot trail will answer the same purpose and is much less expense; consequently, a system of roads and trails not only allows one to quickly reach the location of the fire, but serves to keep a fire from spreading, and is as cheap a protection against loss from fires as can be had. It also makes possible at once the utilization of wood and timber which otherwise would be useless, because of the expense necessary to bring it to market.

Systems of improvement cuttings ought to begin as soon as surveys can be made. The dead and dying trees and undesirable species should be removed and desirable species favored. Where young growth is too dense, thinnings should be made. Pruning may be resorted to, and when mature or hypermature trees are still standing, unless needed as

mother trees, they should be removed and marketed. Some of this work may be an expense, but this expense may justly be considered capital invested, for the result is an increased value of the forest. Nothing is lost and much is gained. Should a profit be made, it means an increase in the rate of interest.

On most of the reserves, if not on all, some planting will have to be done. The extent of this work can only be determined after topographical maps have been made. It will be necessary to determine what trees can yield the most valuable wood, in the least time, on a given area, and whether these trees are to be raised on the spot from seeds, seedlings or cuttings. When seedlings are to be used, it is cheaper to establish permanent nurseries than to purchase the stock from nurserymen.

On the Mont Alto Reservation a forest nursery has already been established, and this spring five acres will be devoted to nursery work. It is the intention of the Department of Forestry to plant up the numerous cleared places on the reservation with valuable species. In many cases burned areas and blanks in the forest will be planted up.

To do all this work it is necessary to have trained men. The management of the forest takes into consideration not only the present condition of affairs, but also those of the future that are likely to result from the trend of present conditions. Causes and effects must be known and the methods of producing beneficial results must be practised. Mistakes which cannot be changed for many years can easily be made through ignorance, consequently we need men on each reservation who have a good general education and a special training for their work. On every 5,000 acres there should be a ranger or warden. Such a man ought to be sober, fearless and of considerable intelligence. He may have a nursery to care for; he must study his district and know it thoroughly and everything that goes on in it; at times he will be obliged to superintend the various operations that go on within his range.

The forester who has an efficient corps of rangers has half his work done when once it is planned. A forest of

20,000 to 50,000 acres cannot be comprehended in a year, nor even the local conditions surrounding and influencing the forest. An important step in the management of such a forest, then, is the employment of a trustworthy man of the neighborhood who is acquainted with the people, the land and conditions, to act as superintendent. He can have in charge the protection of the forest against fire and theft, the employment of laborers, when necessary, and can in many ways assist the forester in his duties. All of these reservation officials should be made peace officers, which, under existing laws, would make them both game and forest wardens with power to arrest without first serving a warrant. This may not seem necessary to one unacquainted with the forests and their inhabitants, but by one who has patrolled a forest it can be heartily appreciated. Above all, they should be appointed because of efficiency and not for political reasons.

Experiments to determine what species of trees are adapted to each State, and under what conditions such species are most quickly grown with best results can be made only by each State for itself. Pennsylvania has a splendid opportunity to begin these experiments at once, and already owns an ideal location where such experiments can be carried out. It is on the Mont Alto Reservation. Nursery work has already begun, and there are numerous old fields scattered over the estate which can be used to no better advantage than for demonstration purposes. We are in need of trained men. We have an ideal reserve on which to train men. Then why not take advantage of the opportunity and work out our salvation by establishing upon that reserve a school of practical forestry where young men of the State can learn the art at first hand and under the conditions which they will have to meet within the State?

We have seen the reasons why the State must both encourage private forestry and practise forestry on its own land, what has been accomplished in the past and the necessary steps to take in the immediate future. It remains now for those who know how, to use their influence to carry forward the work.

NEW METHOD FOR THE DETERMINATION OF THE VELOCITY OF LIGHT.

In the decennial publication of the University of Chicago may be found a suggestion by Professor Michelson of a new method of determining the velocity of light. The Professor reviews previous results, contrasts astronomical, electrical and optical methods and processes. Instead of the revolving toothed wheel of Fizeau, he suggests the use of a stationary grating, and by a double reflection of light from stationary and revolving mirrors, proposes to measure the eclipses the light suffers from the gratings. Figures accompany the original article, which make the author's plan clear. He estimates that the velocity of light can be measured to a probable error of only 5 kilometers.—*Scientific American.*

ACTION OF GELATINE UPON GLASS.

"In a paper read before the Académie des Sciences M. Cailletet describes the action of gelatine upon glass and other surfaces. When a glass object is covered with a thick layer of strong glue, the latter adheres strongly when wet, but upon drying it may be detached and carries with it glass scales of different thicknesses which have been lifted from the surface. The glass which is thus treated presents a surface whose designs resemble those of frost on a window-pane, and have a decorative effect.

"M. Cailletet made experiments with gelatine upon different substances, and found that tempered glass was easily attacked, as well as iceland spar, polished marble, fluorspar and other bodies. A sample of quartz cut parallel to the axis of the crystal was covered with two layers of fish-glue; after drying it was found that the surface was attacked and showed a series of striæ which were parallel, rectilinear and ran close together, while in the case of glass the striæ were curved. When certain salts were dissolved in the gelatine, namely, those which were easily crystallized and had no action, there was produced on the glass a series of engraved designs which had a crystalline appearance. Thus a solution of strong glue containing 6 per cent. of alum gave very fine designs somewhat resembling moss in appearance; other salts, such as hyposulphite of soda, nitrate and chlorate of potash, will produce analogous forms.

"M. Cailletet told of the strong mechanical action exerted by a layer of gelatine when drying. If a sheet of cardboard, lead or even wire-gauze is covered with a gelatine solution, the surfaces are seen to curve into the form of a cylinder as the gelatine contracts. Upon thin glass the effect is striking: when a layer of strong glue is spread upon a cylindrical vessel of thin glass the effort which it exerts when drying is sufficient to break the vessel with explosion. When a plate of thick glass covered with gelatine is examined by polarized light a powerful mechanical strain is observed in the glass, and the value of this effect could no doubt be measured."

The foregoing item is from the *Scientific American.* It may be of interest to note in connection with Cailletet's observations on the action of gelatine on glass, that the same has long been known, in this country at least, and has been applied commercially in the production of decorative glass.

W.

THE FRANKLIN INSTITUTE.

Stated Meeting, held December 17, 1902.

Commercial Production of Oxygen from Liquid Air.

By Eugene C. Foster, M.S.

It is my object in this brief communication to outline some work that has been done quite recently in this country looking toward the commercial utilization of liquid air. I shall not attempt to enter into a theoretical discussion nor to exploit the possibilities in liquid air along many lines; but shall confine myself to that which has actually been accomplished or is really in sight.

Some two years ago the eminent scientist, Raoul Pictet, in collaboration with Moriz Burger, read a paper before this Institute, in which he called attention to the feasibility of separating the constituent gases of the atmosphere after having first reduced them to the liquid state. The liquid-air plant in which Pictet made his experiments was then in New York City; with the substitution of a new liquefier, this plant is now in Washington, D. C., and is under my supervision. The paper referred to put into concrete form the suggestions that had been freely discussed among liquid-air men for some time previous, and constituted one of the few scientific presentations of that period concerning liquid air. To Pictet, probably more than to any one else, is due the credit for crystallizing the thought along this line; but within a few months the apparatus constructed under his supervision for the fractional distillation of liquid air has been dissembled at our plant on account of the mechanical difficulties its operation presented.

The problem of getting cheap oxygen from liquid air, therefore, remained unsolved, so far as this country was concerned. I am aware that considerable work has been done abroad in this line, and some of the published reports of what is estimated as being possible in this direction may seem more glowing than our report of what has been done;

but it is worth noting in this connection that even before publishing results or prospects the Columbia Liquid Air Company, owning the Washington plant referred to, has actually entered the market with oxygen from liquid air, and it is now on sale in many cities.

The liquid-air plant consists of suitable compressors, a pre-cooling device such as an ammonia machine, and a liquefier. The latter comprises coils of pipe so arranged that air at high pressure may be released and expanded, such expansion taking place about the coils which carry the inflowing stream of compressed air. This involves the principle of self-intensification; the absorption of heat by the gases in their change from the compressed to the more rarified state causes a certain percentage of the air to be so reduced in temperature as to condense and collect as a liquid.

We have examined a great many specimens of liquid air freshly made, and find that the percentage of constituent gases is not constant; nor does the liquid air made at the beginning of the run always correspond in constituent proportions with that made several hours after the plant has started. We may, for instance, find the oxygen content varying from 20 to 40 per cent., or even beyond these limits.

It has been demonstrated repeatedly that liquid air on standing for some time becomes rapidly richer in oxygen, and it is this fact that first brought forth the suggestion that oxygen might be accumulated in this manner from the atmosphere, the specially attractive thought being that the raw material is quite inexpensive. The question then arose as to how best to throw out the nitrogen, which is not wanted, and retain the oxygen, which is wanted. The difference in their boiling points, scarcely 12° C., is not so great as to make the problem an easy one; and it is with the question of how best to secure this desired end that we have been working. We cannot here give in detail the method used in thus fractioning the sample; but a clear apprehension of the results achieved may be imparted. More exactly, we have a two-fold problem: (1) how to secure liquid air which is initially rich in oxygen; (2) the choice of

a method of evaporation which will yield a rich product with the least possible loss of weight. Given liquid air with a 30 per cent. content of oxygen, if we could confine the loss by evaporation entirely to nitrogen we should have, with a reduction to one-half bulk, a material holding 60 per cent. oxygen; under like conditions, evaporation to two-fifths bulk would yield 75 per cent. oxygen. In one series of experiments recently we started with 31 per cent. oxygen, and after a loss of 61 per cent. of material (about three-fifths), we had secured 65 per cent. oxygen; this indicated a loss of 6 parts of oxygen coincident with a loss of 55 parts of nitrogen. We have since improved on the method used in that case, with much better results; but if we take our results as given—a 65 per cent. product after evaporating 61 per cent. of the liquid air—we find that they are better than results very recently reported by Linde, who secured only a 50 per cent. product under the same conditions; this is assuming that Linde has been correctly quoted by some very careful journals.

The first suggestion made above, that a part of the problem consists in producing liquid air that is initially rich in oxygen, is full of possibilities. With the completion of a series of determinations we are about to inaugurate, we hope to secure more light upon the causes of the variations in the liquefier; our plans include investigations not reported heretofore either in this country or abroad. A successful outcome of these experiments would enable us to run the liquefier with great uniformity for such a percentage of oxygen as we might wish to turn out, thus requiring no further evaporation.

The question of cost is a pertinent one. It must be remembered that the liquid-air plants constructed in this country have from the first been built with a view to turning out comparatively large quantities of liquid air. Certain departures have been made, therefore, from the beaten paths of European construction; the new liquefier to which I referred is no exception to the general rule which has prevailed, and the present plant, in several important details, is costly in comparison with one which we shall later

construct in the light of experience gained. Yet I propose to show you a remarkable cheapening in cost of oxygen over the chemical method of production, even with the present plant.

The new liquefier of the Columbia Liquid Air Company yields from 12 to 18 gallons of liquid air per hour, with an expenditure of 150 horse-power. For purposes of computation we shall take 12½ gallons, which is close to our minimum and not our average. In a run of ten hours this would therefore yield us 125 gallons of liquid air. If we place the cost of power at 1 cent per horse-power hour, we should have a cost of power of $15. Estimating, with a very large margin of safety, that this will yield us liquid air containing initially 35 per cent. oxygen, we should secure at least a 70 per cent. product by evaporating to two-fifths bulk, or 50 gallons. This should yield us 5,000 cubic feet of gas, at a cost of three-tenths cent per foot for power and raw material.

In answer to those who will say that this does not compare favorably with other estimates made on this subject, both here and abroad, I beg to say that this is not a theoretical estimate, but the conclusion reached in practical experience when based upon the cost of power suggested. Six months from now we expect to be able to make these figures look very large.

We produce a 70 per cent. material for sale as medicinal oxygen unless a different percentage is specified. It is conceded by many leading physicians that an oxygen approximating 100 per cent. purity would be unsafe for direct administration; and the effort to secure an admixture of air would only result in administering a product of unknown composition. On the other hand, a number of leading makes of medicinal oxygen have been examined, and only two specimens of those tested have gone over 50 per cent. oxygen. The 70 per cent. grade is deemed the best in cases of pneumonia and like conditions, and gives all the stimulation required, and is safe where resuscitation is aimed at. The advantage of definitely knowing what percentage is available is one not to be lightly considered.

The medicinal use of oxygen is one that has grown with remarkable strides within the last few years. The increase in this business alone in the next decade gives promise of being beyond present means of computation. Where a few years ago scarcely a hospital found it necessary to keep a stock of oxygen on hand, now not a modern institution is without it, and hundreds of physicians keep it in their private offices. The advantage of producing an oxygen which cannot by any means become contaminated with chemicals, such as the chlorine of the chemical process, is so apparent as to need no comment.

Large quantities of oxygen are used for the oxy-hydrogen light and in the industries. To what extent its use will be augmented along commercial lines no one can estimate, as the question is simply one of cheapness of production. It will readily be seen that the lower limit of cost is not in sight when made by the liquid-air process, for this process is but in its infancy and is bearing all the burdens of preliminary experimentation.

AMERICAN NITER INDUSTRY.

The recent discovery, in California, of extensive deposits of nitrate of soda of good quality, and the occurrence of that mineral in Nevada and some States on the Pacific Coast, is attracting capital from professional and business men, principally in the East. Much land is being taken up in California, and at least one large company with influential backing intends to undertake systematic development.

The California nitrate deposits are located in the Mohave Desert, extending from the northern portion of San Bernardino County to the southern section of Inyo County, and are 80 or 100 miles from Manvel, on the Santa Fé Railway. Some very high analyses of the mineral are reported, and it is estimated that there are about 22,000,000 tons in sight, though these figures are likely to be revised when active mining is in progress. It is believed, however, that the deposits are richer than the Chilean. At present the American Niter Company, whose president and promoter is W. W. Treat, of Boston, is planning large development. The company was formed in 1901 and controls about 35,000 acres, which have been located by the Baileys, of San Francisco, and others. Dr. Gilbert E. Bailey is the consulting engineer of the company. It will probably take two or three years before the property is in condition to ship to market, and by that time we may expect to hear something of interest concerning the Chilean combination, whose agreement expires in April, 1905. —*Charles C. Schnatterbeck, in Engineering and Mining Journal.*

THE CARNEGIE RESEARCH SCHOLARSHIP.

The Iron and Steel Institute calls attention to the scholarship to be awarded under the gift made to the Institute by Mr. Andrew Carnegie. The object of this scheme of scholarships is not to facilitate ordinary collegiate studies, but to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches in the metallurgy of iron and steel and allied subjects, with the view of aiding its advance or its application to industry. There is no restriction as to the place of research which may be selected, whether university, technical school or works, provided it be properly equipped for the prosecution of metallurgical investigations. The appointment to a scholarship shall be for one year, but the Council may at their discretion renew the scholarship for a further period instead of proceeding to a new election. The results of the research shall be communicated to the Iron and Steel Institute in the form of a paper to be submitted to the annual general meeting of members, and if the Council consider the paper to be of sufficient merit, the Andrew Carnegie gold medal shall be awarded to its author. Should the paper in any year not be of sufficient merit, the medal will not be awarded in that year. Candidates, who must be under 35 years of age, must apply, on a special form, before the end of February, to the secretary of the Institute, at 28 Victoria Street, London. Candidates may be of any nationality.

HISTORY OF MECHANICAL STOKERS.

From an interesting paper on "Mechanical Stokers" lately presented before the Engineers' Society of Western Pennsylvania, by Mr. Edwin Fitts, of Pittsburg, we glean the following:

"As to the history of mechanical stoking, the first to use the idea of progressive burning of coal was James Watt. He distilled the coal on a dead plate at the mouth of the furnace and then pushed the coke back over the grate-area by hand. In this way a fairly good combustion can be obtained, but the labor is very excessive. Many variations of this plan were brought out from time to time, but the first mechanical stoker was patented in 1841 by John Juckes, an English inventor. This was of the tread-mill type and is in extensive use to-day, having been changed in detail of construction, and is now known as the chain-grate stoker."

DURABILITY OF THE PRESSED-STEEL CAR.

Almost every day brings forth some evidence of the extreme durability of the pressed-steel car. A few days ago in Pittsburg, one of these cars while being shifted was sent down a track which ran close to a stone wall of very substantial construction in the Panhandle freight yards. The brakes failed to work at the proper time and the car crashed into the bumper with terrible force. The upper part of the car was forced over the bumper against the stone wall, which was cracked in four places and which had every appearance of being ready to fall when it was taken down. The car was not seriously damaged, and on being placed on the tracks again was able to resume its trip without any attention whatever.—*Scientific American.*

PHYSICAL SECTION.

Stated Meeting, held April 24, 1901.

The Contributions of H. F. E. Lenz to the Science of Electromagnetism.

By W. M. Stine, Ph.D.

(*Concluded from p. 3 4.*)

PART II.

Heinrich Friedrich Emil Lenz was a voluminous writer as well as an indefatigable investigator, most of his experimental work having been done while he was a professor of physics at the University of St. Petersburg. The catalogue of the Royal Society contains a list of some fifty of his contributions. But little biographical information concerning him is available, probably owing to his residence having been so remote from the intellectual centers of Europe, and for the further reason that scientists, like other skilful artisans, scarcely leave any record but that of their experiments and papers; and probably there is an additional reason to be found from the fact that society at large, out of a requital for the scientist often having eschewed and neglected the humanities, forbears to consider his own life as a human document worthy of preservation. The author of the most insignificant literary work usually leaves enough of his life on record to show what the manner of the man was; but from the silence of social records, one must usually take for granted that the scientist was a man fulfilling at least the ordinary round of human life.

From brief encyclopædic notices in the French and German it is learned that Lenz was born February 12, 1804, at Dorpat, or the Russian Yurief. He seems to have studied theology in the earlier portion of his professional preparation; but, abandoning this subject, he devoted his attention to the natural sciences, and especially physics. What an

interesting chapter this portion of his life would furnish! In 1823–26 he accompanied O. von Kotzebue, the son of the celebrated poet, on the second of his voyages around the world. He traveled on this journey in the capacity of a naturalist, and upon his return made a valuable report of his observations to the Imperial Academy of Sciences at St. Petersburg. In 1828 he was elected an adjunct of the Academy, and in 1834 was made a fellow (Akademiker). About this time he became Professor of Physics at the University of St. Petersburg, and also taught the subject of physics at the Pedagogical Seminary. In 1864 he published a "Handbook of Physics," in two volumes. He at one time was the rector of the University and also served as its counsellor. His health failing, he made a journey to Italy, where, on February 10, 1865, he died at Rome.

Among the brief notices of the life of Lenz, there is one which for singularity deserves to be quoted at some length.* It proceeds with "Lenz was a German physician, and was afterward Professor of Medicine at the University, and numbered among his pupils the imperial princes (sons of Nicholas I)." That the subservience of Lenz to a few royal children should be his leading claim to public notice, while not a word is awarded to his scientific achievements, is a suggestive reflection on the material which passes for learning in our country. But even this brief notice is seen to be ludicrous when it is observed that the German "Physik" and "Physiker" have been translated "medicine" and "physician."

In order to acquire some familiarity with the intellectual complexion of Lenz, the few contributions which he made prior to his classical papers may be examined with interest. His mind was evidently of an eager, inquiring character, and apt to be absorbed by the dominant ideas of his time. The first paper has to do with "Considerations on the Temperature and Salt Content of the Water of the Ocean at Different Depths."† His second was a "Report of a Journey to

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* "Lippincott's Biographical Dictionary," 1895.

† Pogg. Ann., XX, 1830, pages 73–130.

Bakou," and its contents were of a geological character. The third carries the pretentious title, "Physical Observations Made during a Voyage around the World in the Years 1823–26." These were followed by a second paper on the "Comparative Quantity of Salt Contained in the Waters of the Ocean,"* and in a fourth by some observations on the influence of temperature of the objects weighed on the movements of the beam of a balance. Finally, a sixth paper was devoted to "Variations that the Height of the Surface of the Caspian Sea Has Suffered to April (*sic*) of the Year 1830."

His first contribution of general scientific interest was the seventh in the list of his papers and was entitled, "On the Laws According to Which the Magnet Acts upon a Spiral When it is Suddenly Approached to, or Withdrawn from it; and on the Most Advantageous Method of Constructing Spirals for Magneto-electrical Purposes,"† which was read before the Scientific Academy at St. Petersburg, on November 7, 1832. It is significant to note the date of this paper in comparison with similar communications by Henry‡ and Faraday.§

In this paper Lenz frankly makes mention of Faraday's published experiments and states that he promptly repeated the principal ones. It will be seen from his own statements to what extent he verified the work of another, and how far he is entitled to be considered an original discoverer of the various phenomena of electricity induced from magnetism. In his own words from the English translation of his paper: "From the great interest which the late discoveries of Faraday in the field of electromagnetism must awaken in all the natural philosophers of Europe, it is to be expected that we shall soon receive many and various explanations. Up to the present moment we, here in the North, are only acquainted with the papers of Becquerel, Ampere, Nobili and

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* Trans. in the *Edin. Jour. of Sci.*, VI, 1832, page 341.

† Eng. trans. by W. Francis, in Taylor's Sci. Memoirs, I, 1837, page 608; from Mem. Imp. Acad. des Sci., St. Petersburg, 1833, Vol. II, page 427.

‡ Published in October, 1832.

§ Read February 17, 1832.

Antinori, and Pohl; and as none of these authors has occupied himself with that branch of the subject to which I have directed my particular attention, I hasten to make known, as quickly as possible, the following contributions to the science of electromagnetism."

After successfully repeating the experiments of Faraday, Lenz applied himself as an investigator to find out how the phenomena of the magnetic action on a spiral, suddenly approached or removed from the magnet, might be produced in the easiest and most powerful manner. For this purpose he foresaw he must determine in what respect the characteristics of the "electromotive" spiral, as he called it, influenced the phenomena. The characteristics which he studied were:

I. The number of convolutions in the spiral.

II. The breadth.

III. The thickness.

IV. The substance of the convolutions.

The galvanometer which he employed was constructed with Nobili's double, or astatic needle; and was wound with seventy-four turns of 25-mil wire. "I wound," Lenz states, "the electromotive wire about a soft iron cylinder, which served as an armature, and was filed smooth and flat at those places where it was laid on the poles of the magnet. As the removal of the armature can be performed in a more certain, prompt and uniform manner than the placing of it on the poles, I have, in all my following experiments, given the results which were obtained by pulling away the armature, or by the sudden removal of the magnetism of the iron." With these elaborate preparations, Lenz proposed to investigate the various factors in the induction of electrical currents by the magnet. In passing, it is noteworthy that Lenz in this paper refers to the laws which Ohm had established for the electrical circuit, and he intimates that he had discovered these laws and relations for himself.*

He expresses the results of his experiments in a number of generalizations. In the first of these he states: "The

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* Reference cited, page 613.

electromotive power which the magnet produces in a spiral with convolutions of equal magnitude, and with a wire of equal thickness and like substance, is directly proportional to the number of its convolutions." In modern phraseology, if a coil of n turns is moved in a magnetic field of strength N, the electromotive force in volts is defined by

$$e = -\frac{dN}{dt} \times \frac{n}{108}$$

In this generalization, then, Lenz has established a principle which is of fundamental importance, though from lack of all knowledge of the magnitude of the magnetic field which he employed, the effect of the time-rate-of-change of the magnetic field escaped him.

With respect to his second series of experiments, he states: "I wound the copper wire in six convolutions around a wooden wheel 28 inches in diameter, and placed the wheel on the iron cylinder. After having completed the experiment, I wound six convolutions of the same wire about the same iron cylinder." The electromotive power in each case was nearly identical; hence he concluded that "The electromotive power which the magnetism produces in the surrounding spiral is the same for every magnitude of the convolutions."

In his third investigation he employed coils of ten convolutions or turns, in which the wires were of different diameters, while he made for his tests three separate coils. The length of the wire in each case was 33 feet, and as the copper wires were short and relatively of large section, their resistance seems to have been negligible. The coils were tested successively on the same iron cylinder with the result that the electromotive force induced was practically constant for the three coils. His conclusion was, "The electromotive power produced in the spirals by the magnet remains the same for every thickness of the wires, or is independent of it."

The final conclusion is perhaps the most interesting of the series and the most important in its consequences. He proved very rigidly that "The electromotive power which

the magnet produces in spirals of wire of different substances, under like conditions, is the same for all substances." From one point of view this conclusion is correct and rigid, but for ferro-magnetic substances, while it still holds true, the permeability of such conductors being greater than unity, the element dN is affected and masks the results, though this refinement he was seemingly unable to detect. To show how thoroughly Lenz had grasped the principles of the electrical resistance of conducting substances and circuits, his own remarks will be placed in evidence. In discussing the experiments leading to the fourth conclusion, he says: "Nobili and Antinori, in their first paper on the electrical phenomena produced by the magnet,* have already determined the order in which four different metals are adapted to produce the electric current from magnetism. They arrange these in the following order: copper, iron, antimony and bismuth." He then observes: "It is particularly striking that the order is the same as that which these metals occupy also in reference to their capacity of conducting electricity; and the idea suddenly occurred to me, whether the electromotive power of the spirals did not remain the same in all metals, and whether the stronger current in the one metal did not arise from its being a better conductor of electricity than the others. With this in view, I examined four metals: copper, iron, platinum and brass." His method of experiment was simple and conclusive; spirals identical in form were made of the several metals and these were tested, pairing two of them at a time by connecting them by series into a single circuit whose free ends were connected by copper lead wires to a galvanometer. He placed now one spiral and then the other on the soft iron armature of the magnet. There was thus no change of resistance in the experiment if the electromagnetic conditions for induction were constant; and he should thus have obtained an equality of inductive effect. Between the circuits containing the pairs of coils he made full allowance for the elements of their resistance,

* Pogg. Ann., No. 3, 1832.

and upon calculating the electromotive power in unit terms for each coil, he found the values agreed remarkably well for the entire series of tests. To show the care with which he proceeded, he took pains to avoid any thermo-electric action at the joints. Thereupon he derived a law which he thus phrases: "The electromotive power which the magnet produces in spirals of wires of different substances, but in every other respect placed in exactly the same conditions, is completely identical for all these substances."

From the present time, though deservedly we look back upon the work of the noted classical investigators and call it great, yet from our prevalent ignorance of the mental attitude of these men toward their work, it acquires in our eyes almost a reverent aspect, and we imagine these men to have been gigantic in their intellectual grasp, when often they were most puerile. To show how these investigators often worked in the dark, and how, as a result, they made great ado over nothing, Lenz may again be quoted in illustration. Still speaking of his experiments with his electromotive spirals, he adds: "The conducting wires were connected with the ends of this spiral only by a single twist of the wires; the result of four readings with the connection in circuit amounted to 36·8°; upon this the same connection was made by twisting the ends of the wires ten times around one another as tightly as possible; the deviation again amounted to 36·8°. I finally pressed the last connections as tightly as possible with a pair of pincers, so that they were very much flattened; the deviation was 36·75°. We may therefore consider the connections made by tightly twisting the wires ten times around one another as quite sufficient."

In connection with the description of his experiments he, from his conception of the sine galvanometer, analytically investigated the magnitude of the currents produced. This work was done with some show of skill; but from a lack of full discrimination between ballistic and static deflections, the results obtained have considerable error, though this did not affect them since they were usually of similar magnitudes. It is indicative of the methods of Lenz that all his

results are corrected by least squares, a refinement far in excess of his possible instrumental accuracy.

In the final conclusion to his paper he proceeds to investigate the conditions for maximum electromotive power by deriving algebraical relations from his data. These interpretations of his experiments are rather formal and academical, and perhaps would be called crude in comparison with prevalent standards, and they would have been much more elegantly expressed by differential methods with which he shows himself to have been familiar by their introduction in later papers. Some of the quantities which he employs are based on bald assumptions; though by these means he arrives at some conclusions which appear to have been satisfactory to himself, they are devoid of interest to the present-day reader.

There have now been placed here, in their due order, the practically identical results of the leading scientists who laid the experimental foundations for the science of electromagnetism. Faraday and Henry are entitled to equal honors for the initiative work of discovery. The work of Lenz in comparison was to assign magnitudes and verify the phenomena, and later on to formulate a most important generalization. Of the three investigators, Faraday showed genius pre-eminently, for he sought after the causes of the phenomena, and developed the useful working hypothesis of tubes of force. Both Faraday and Henry neglected to attempt any mathematical statements and deductions from their experiments—Faraday from a lack of working knowledge of mathematics, and Henry because he evidently was not fully accustomed to the attitude of mathematical natural philosophy.

Again, of the three, the work of Lenz best stands comparison with modern methods, and he is pre-eminently the precise and analytical scientist seeking for relations and magnitudes. However, Lenz impresses one upon studying his work, as being singularly devoid of originality, and as being more nearly empirical, for he sets about his experiments largely in the spirit of the skilled workman who carefully examines every possible phase so that nothing may

escape him. Though this may be commendable, Lenz was seemingly not inspired by a high degree of the philosophical spirit and insight. One is impressed, however, upon reading the writings of Lenz, with the clear conception he displays of the momentary character of the induced currents. He undoubtedly realized that their action on the galvanometer-needle was ballistic, though he was in error in the estimation of the magnitudes of the current.

Following the first of what may be called the exact investigations of Lenz, in which he is undoubtedly entitled to precedence for determining the conditions upon which the magnitude of the electromotive force depended, he seems to have devoted himself to questions of electrical resistance. At first giving attention to the laws of divided circuits, he solved a number of intricate problems for the resistance of compound circuits.* However, it was in a paper read before the Academy at St. Petersburg, June 7, 1833, that he most clearly revealed his powers as an investigator. This paper was entitled, "On the Conductivity of Metals for Electricity under Varied Temperatures."† In it he states: "I had anticipated that there would be found a relation between the expansion of the metal under the action of heat and its lowered conductivity for electricity." He had examined copper, brass, iron and platinum, but by no means could he find any such temperature change of resistance as he anticipated, through the formulas which he employed for calculating the results of his experiments. But when he had developed his experiments on induced currents, he found through them a new means for further investigations of the supposed change of resistance; for he was thus enabled to put upon the circuit tested an electromotive force free from the uncertain element of the internal resistance of a battery which he had hitherto employed. Being able now to ascertain the resistance of all the elements of the circuit, he at once found and measured the temperature effect on the resistance of metals. To Lenz may be attrib-

* Dove's Reportorium, Bd. VIII.

† Pogg. Ann., Bd. XXXIV, page 418.

uted the priority in investigations of these phenomena and also their formulation; for he derived from his experimental data the expression

$$Yn = X + Yn + Zn^2$$

which may be recognized as the original for the now prevalent formula,

$$R_t = R_0 (1 + at + \beta t^2)$$

Usually only Matthiessen is mentioned as the authority for temperature changes of resistance, but the historical succession of authorities is Lenz,* Becquerel,† Arndsten ‡ and Matthiessen §.

As a second result of the possession of the new and powerful means of investigation which the electromotive spirals had placed in the hands of Lenz, he promptly developed the necessity for some unit of resistance, and indeed employed this in terms of a unit length of copper wire of a definite section. The paper describing these experiments was read before the Academy, November 28, 1834, and was entitled, "On the Laws of the Conducting Powers of Wires of Different Lengths and Diameters for Electricity."‖ In this paper Lenz discusses Ritchie's observations on "conductibility"¶ and shows him to have been in error. He thereupon undertakes a lengthy discussion of the similar work of Ohm and Fechner, and in the course of his remarks he employs simple algebraic methods to phrase Ohm's law for simple and compound circuits, expressing his meaning through forms of analysis which are still accepted. Lenz, in his experiments, determined the resistance by the method of substitution, the current being obtained through electromotive spirals. His analysis begins with an expression of the familiar form,

$$J = \frac{E}{W} \qquad (1)$$

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* Pogg. Ann., Bd. XXXIV and XLV.

† Pogg. Ann., Bd. LXX.

‡ Pogg. Ann., Bd. CIV.

§ Pogg. Ann., Bd. CXV and CXXII.

‖ Taylor's Scientific Memoirs, Vol. I, page 311.

¶ *Phil. Trans.*, 1833, page 313.

J being his symbol for current strength, and W the resistance of a simple circuit including the spiral, lead wires and the galvanometer. A standard resistance of copper wire was then inserted, whose length was l, and whose resistance in terms of his unit copper wire was $\frac{l}{c}$. Then it followed that

$$J' = \frac{E}{W \frac{l}{c}} \tag{2}$$

and by combination,

$$W = \frac{l}{c} \frac{J'}{J - J'} \tag{3}$$

from which W was determined in terms of $\frac{l}{c}$.

Then substituting for the standard resistance the wire whose resistance R he wished to ascertain, he found, by solution of an expression, its resistance. J'' being the current in this case,

$$R = W \frac{J - J''}{J''} = \frac{l}{c} \frac{J'}{J''} \frac{J - J''}{J - J'}. \tag{4}$$

In this manner he obtained values for the conductivity of silver, copper, gold, iron, tin, lead, mercury, platinum, and many other conductors. Despite his crude standards for current and resistance, his methods are remarkably successful and the results are very close to the data which Matthiessen subsequently determined.

Throughout the discussion in this paper Lenz reveals a clear and concise grasp on his subject-matter, and exhibits a characteristically fine and well-trained mentality. He refers to Ohm's law as an axiom; and summing up his results, he states:

"The conductibility of wires of the same substance is inversely as their lengths and directly as their sections." Regarding this law as sufficiently proven, he continues, in explanation: "Still the method for determining the conductibility by the induced electrodynamic current offers so much facility and accuracy in observation that it appears to me worth while to apply this method." He had con-

ceived that some variations in the resistance of the battery employed as a source of electromotive force had been responsible for discrepancies in the results obtained by other investigators; and in contrast he considered his own source of electromotive force was, however, free from changes in internal resistance. At this time he had not yet grasped the conception which we now phrase under the term "impedance," though later on he developed this with much clearness. However, his circuits were low in reactance, and no doubt the small discrepancies, which at first he could not explain, were due to this effect; otherwise these methods were remarkably simple and effective. Probably nothing could more clearly illustrate that the first approximation of a scientific principle is often very simply obtained, and usually carries with it a degree of fame that is denied its elaborate and subsequent verification.

Though Lenz was not to receive wide recognition as one of the original discoverers of the phenomena of electricity induced from magnetism, yet his chief fame was to rest upon one terse and valuable generalization, which was to be known as Lenz's Law, and which was to serve for placing these phenomena under the broad generalization of the conservation of energy, soon to be developed and generally received, and which law should further prove one of the most practical for the application of the principles of electro-magnetic induction to electrical machinery. The enunciation of this law was first given in a paper read on November 29, 1833, before the Academy at St. Petersburg; it bore the caption, "Concerning the Direction of Galvanic Currents Excited by Electrodynamic Distribution." *

In its introduction Lenz takes exception to Faraday's rules,† and considers them insufficient, if not in error. He briefly summed up Faraday's statements to read: "(1) Be-

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* Pogg. Ann., 1834, Bd. XXXI, page 483. The exact title of the paper is of interest; as it was first given scientific publication in the German, it reads, "Ueber die Bestimmung der Richtung der durch elektrodynamische Vertheilung erregten galvanischen Ströme."

† He had read these statements from Pogg. Ann., No. 5, 1832. Compare "Experimental Researches," Vol. I, pages 32–3.

tween parallel conductors, one of which carries a current, an opposing current is induced upon approach, and a current similarly directed upon withdrawal from the first conductor. (2) When a conductor is moved near a magnet the direction of the induced current depends upon the manner of cutting the 'magnetic curves.'" Lenz objected to this, and insisted that Faraday had here stated two wholly different laws for one and the same phenomenon. He based this singular objection upon what he calls "Ampere's beautiful theory," which regarded the magnet as a system of circularly directed galvanic currents. The objection, it must be confessed, appears trivial, and leaves Lenz open to the implication that he wholly failed to grasp the important significance of the magnetic curves or lines of force which Faraday had supposed constituted the magnetic field; and it further lays Lenz open to a suspicion that he was zealous for some opportunity to criticise the magnificent discoveries and work of Faraday.

This attitude of Lenz is all the more singular, since his first investigations proved conclusively that the cause of induction lay wholly apart from and without the circuit in which it took place; or, more briefly, in a medium surrounding it. Faraday clearly considered a magnet and a wire carrying a current as identical so far as they were both accompanied by magnetic curves; so his statements referring to two sets of conditions were very properly phrased into one general law. Again Lenz was correct in assuming that both the relations which he noted were aspects of one and the same phenomenon; his mistake originated wholly from adherence to Ampere's theory, and the failure to appreciate Faraday's conception of a magnetic field; though nearly all scientists and mathematicians at first were equally averse toward accepting this assumption of lines of force.

Since the processes by which Lenz finally arrived at his classical law are largely dominated by the criticism of Faraday's work, his objections will be given in some detail. In placing a stricture on the generality of Faraday's rules he instances the case of a conductor placed perpendicularly

to a second one in which a current is established. According to the interpretation which he placed on Faraday's rules, no current would be induced in this conductor when moved parallel with itself and with the inducing conductor. But this stricture is an obvious one since Lenz was inclined to be empirical rather than philosophical; and what should have led his thoughts to a conception of a field of force only in the end suggested to him an empirical generalization.

Faraday, in order to illustrate the sense of direction of the induced current relative to the polarity of the magnetic field inducing it, had resorted to the suggestion of a silver knife-blade, whose notched side was considered to be placed upward as it was moved along a bar, or cylindrical magnet, its edge cutting the lines of force. Lenz did not spare something of a sneer at the homely illustration, and considered it but an instance of the stricture he had placed on the supposed general law, since the knife-blade in fact was perpendicular to the axis of the inducing magnet, and should accordingly have had no current induced in it; a supposition which would have been true only for the position near the center of a very long straight magnet. The illustration, however, was a very apt one, and had in it something of the inspiration of genius on the part of Faraday, and its criticism showed the lack of this on the part of Lenz.

Upon the further study of Faraday's papers, and Nobili's comments upon them and his own experiments, the impression grew upon Lenz that all related electrodynamic distribution of currents might be simplified and brought together under the statement of a single, terse and comprehensive law; and guided by this idea, he entered upon a repetition, verification and extension of Faraday's experiments immediately following those by which he had established his discovery of the induced current. Lenz, through these experiments which he now instituted, was finally led to the elegant, though for him empirical, generalization which alone has made his name familiar to every student of electricity, and which serves more than any other detail to

make his investigations and papers classical. Stated in the language of its author, Lenz's law reads: *

"Wenn sich ein metallischer Leiter in der Nähe eines galvanischen Stromes oder eines Magneten bewegt, so wird in ihm ein galvanischer Strom erregt, der eine solche Richtung hat, dass er in dem ruhenden Drahte eine Bewegung hervorgebracht hätte, die der hier dem Drahte gegebenen gerade entgegengesetzt wäre; vorausgesetzt, dass der ruhende Draht beweglich nur in Richtung der Bewegung und entgegengesetzt wäre."

In a well-known and widely used text† the law is phrased in a form perhaps more familiar to the general reader, and is stated thus: "If the relative position of two conductors A and B be changed, of which A is traversed by a current, a current is induced in B in such a direction that by its electrodynamic action on the current in A, it would have imparted to the conductors a motion of the contrary kind to that by which the inducing action was produced."

The law expressed more tersely is: *The electrodynamic action of an induced current opposes equally the mechanical action inducing it.* When expressed in this form it is seen at once to be a corollary of the general law of the conservation of energy. Had Lenz expressly anticipated some such significance in it, his title to fame as a natural philosopher would have been established. However, the equivalence of the energy relations between the inducing and the induced currents did not seem to have occurred to him, his attention having been entirely absorbed by the mechanical relation detected in his experiments. It was not until some fourteen years later, when the principles of the conservation of energy were beginning to be grasped, that Helmholtz showed this law was a necessary corollary of the more general principle.

In order to obtain an idea of the working conceptions of induced currents which obtained among certain scientists in the early stages of the development of the science of

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* Pogg. Ann., Bd. XXXI, page 483.

† Atkinson's Ganot's Physics.

electromagnetic induction, I translate a passage from the introductory discussion of Lenz's law, which Neumann gave in 1845.* It is to be recalled that Neumann gave mathematical expression and formulation to much of Lenz's work, as Maxwell did for that of Faraday. Neumann says:

"From the law of Lenz: the action which the inducing current or magnet exercises upon the induced conductor, if the induction results from the movement of the latter, is always in the nature of a check on its motion. And, further, the strength of the momentary induction is proportional to the velocity of the movement. From these considerations the general law of linear induction may be derived; and

$$E.\, Ds = - \varepsilon\, \nu\, C.\, Ds$$

In this formula, Ds is an element of the induced circuit, and $E.\, Ds$ is the electromotive force induced in the element Ds; ν is the velocity with which Ds is moved, while, according to the direction in which Ds is moved, C denotes the magnitude of the resolved action of the induction upon Ds when unit current is considered to be flowing in this element. The magnitude of ε is independent of the activity of the induced conductor, and in the case of linear induction may be regarded as a constant; but it is a function of the time, which decreases rapidly if its argument attains a finite value."

These views of Neumann are those of the pure analytical mathematician, and make no effort after a physical explanation of the phenomena or of their causation. They are based wholly on experimental results and are devoted to the establishment of relations between the various data. What is lacking in them is that physical aspect so finely expressed by Faraday in his conception of magnetic curves or lines of force. The pre-eminence of Faraday in this respect not only over Neumann, but Lenz more especially, is emphasized when it is considered that Lenz was so occupied with Ampere's theory of the magnet, that he did not

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* Die math. Gesetzen der inducirten elektrischen Ströme; 1845, Engelmann, page 4.

go beyond it; while Faraday, as fully conversant with "M. Ampere's beautiful theory," * as he calls it, found this inadequate and established the conception of the magnetic field.

Lenz, in order to make his law clearer, proceeded to phrase it somewhat differently, though again missing the perception of its greater significance: "To each phenomenon of movement by electromagnetism there must correspond an electrodynamic distribution. Consequently, it is only necessary to produce motion through other means in order to induce a current in the movable conductor which shall be opposed in direction to that so produced in the electromagnetic experiments."

His attack on the proof of his law is logically arranged and carried out experimentally where data were not otherwise at hand. As stated, the items were, the dynamic fact being stated first, and the reversed inductive action second:

A. By Ampere's rule for parallel currents, two similarly directed currents mutually attract; while if oppositely directed they repel each other.

a. From Faraday's experiment, if a current is flowing in one of two parallel conductors, when the other conductor is caused to approach, a current of opposite direction is induced in it; and conversely.

B. By what became in subsequent years the principle of the electrodynamometer, if two circular currents are vertically placed with their planes at right-angles, having a common diametral axis of rotation, be the one fixed and the other free to move, the movable circuit will rotate until the two planes coincide and the currents have a common direction.

b. If two circuits are arranged as above, when the movable coil is quickly brought from a position of quadrature of its plane to one of coincidence with the fixed coil, a current is induced in the movable coil opposed in its direction to that in the inductor. This supposition was experimentally established by Lenz himself; and in it is recognized the principle of the earth inductor. In the apparatus used by

* "Experimental Researches," page 10, art. 38.

Lenz the circular frames were each wound with twenty turns of copper wire.

C. From an experiment of Nobili,* if from a fixed conductor, so long as to be considered as infinitely rectilinear, a short conductor be arranged at right-angles, and being free to move, be connected as a shunt from the fixed conductor, the direction of its current flow being from the fixed conductor, the shunt will move in the direction of the flow of the first current; and conversely.

c. If a shunt conductor, as above, be moved in the direction of the flow of current in the inductor, an induced current will be established, whose direction of flow is toward the inductor, or opposed to the direction in *C;* and conversely.

These, Lenz states, he considered the principal cases in which a galvanic current exercises an electrodynamic and an electro-inductive action upon an appropriate conductor. He then proceeded to examine the cases of mutual reaction between currents and magnets. These he prefaced with a discussion of Ampere's rule for finding the direction of an induced current by the friction of a man swimming in the circuit; and with something like perversity, proposed a modification derived from his own law. He gave as a rule, "If a conducting circuit is moved before the north pole of a magnet, an induced current results from the electrodynamic distribution, which streams through from the head to the feet, if one should be imagined to be in the circuit turned so as to view the north pole, and the motion of the conductor be toward the right hand." Just what conception Lenz himself had of this electrodynamic distribution (elektrodynamische Vertheilung) can not be obtained from his writings, if indeed he went so far as to establish a working conception for it. In his experiments he seems to have dealt with this electrodynamic distribution in the same sense that Faraday did with magnetic curves.

Proceeding to discuss the reactions between magnets and currents, Lenz resumes:

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* Pogg. Ann., No. 3, 1833, page 407.

D. From Oersted's experiments, a galvanic current brought over a magnetic needle, the direction of the current being from the south toward the north pole, will deflect the north end of the needle to the right.

d. If a linear conductor is placed over a magnetic needle at rest, and the needle is suddenly deflected by some force, a current is induced whose relation of direction is opposed to that in *D;* or, if the north pole of the needle is deflected toward the right, the flow of current will be from the north pole toward the south; and conversely. To prove this experimentally, Lenz employed a frame 1 foot square, wound with many turns of fine silk-covered copper wire.

E. From De la Rive's experiment, if a circular current, free to move, surround a long, cylindrical magnet, and the direction of its current coincides with the resultant direction of the Amperean magnetic currents, the conductor will move toward the center of the magnet; while if the direction of the two currents be opposed the conductor will tend to push out over the nearer pole.

e. If a circular conductor be thrust over an end or pole of a bar magnet, a current will be induced whose direction will be opposed to that of the Amperean currents of the magnetic pole. Should the circular conductor be removed quickly from the magnet, the induced current will have the direction of the Amperean currents. This result Lenz takes from Faraday's experiments.

F. By the experiment of Barlow with a rotating wheel, if a bar magnet is placed diametrically over the wheel with the north pole toward the left, and a current flows from this point on the periphery toward the center, the wheel will rotate in a clockwise direction; and conversely by changing the relative direction between current and pole.

f. Faraday, varying the experiment, still keeping the axis of the wheel vertical, placed the north pole of a curved magnet over a point on the periphery of the wheel, and the south pole beneath. Upon turning the wheel in a clockwise sense, a current was induced from the center toward the periphery; and conversely.

G. By Ampere's experiment a cylindrical magnet, rota-

table about its axis, will rotate in a clockwise sense regarding its north pole, when a current passes from the north pole to the center.

g. Faraday showed when such a magnet is rotated in a clockwise sense, and a galvanometer is connected to its center and the upward-pointing north pole, a current is induced whose direction is from the center toward the north pole; and conversely.

The contributions which Lenz has made toward the establishment of the science governing the phenomena of magnetically induced electrical currents have here been presented, and the relation which his work bears to that of others, perhaps more widely known, has in a manner been pointed out. As an investigator, Lenz is no doubt entitled to the honor of being one of the foremost scientists who established the principles of electromagnetism. The sensationalism of discovery seems not to have been reserved for him; and there is much evidence that he lacked originality and that his work was largely shaped by the hints he obtained from other investigators, rather than that it sprang from his own initiative. Neither in his writings nor experiments can he be called brilliant; he perhaps did little that would not subsequently have been done; yet all his work was of that solid, enduring character which forms the foundation of all science. His work was painstaking and exhaustive; he verified, extended and formulated. His papers exercised a wide influence on the development of electromagnetics, especially in Germany and France, and in one respect at least they were the most noteworthy of the period; and this respect is most essential, for in all his work he seems to have been guided by the quantitative aspect of science. In this sense the writings of Lenz seem modern, especially when compared with those of Faraday and Henry, or of Ampere and such contemporaries.

The present intention has been to bring the work of Lenz into prominent notice only so far as it was contributory to the discovery and development of magnetically induced electricity. But this represents but a portion of

the scientific labors and contributions of Lenz. Much of his subsequent work was important, and all of it more or less influential, but it has less general interest than that here given in detail. A mere outline of his subsequent work, however, will be given.

Lenz investigated Grove's battery quantitatively,* and certain aspects of electrolytic polarization, and the internal resistance of batteries.† He made a notable contribution on the cooling effect of a current passed through the junction of a thermo-electric couple.‡ Soon after Joule published his law for the heating effect of the electrical current, Lenz proceeded to investigate the entire subject with characteristic thoroughness, and gave Joule's law perhaps its most rigid verification, conspicuous also for its completeness.§

Lenz seems to have been especially keen to have recognized in the electromotive spirals an instrument for investigation capable of wide and exact application. By use of these spirals, he conducted numerous tests and measurements, which in method and apparatus very closely resemble modern permeametry in its simpler forms. With the aid of Jacobi he found a parabolic relation between the strength of the magnetization of an iron rod and the magnetizing current employed; and they also measured the magnetic moment for various types of magnets.||

There was an additional line of investigation to which Lenz applied himself with the greatest enthusiasm and certainly with signal success; and this was a study of the properties and characteristics of the magneto-electric generators. He was led to establish experimentally that the plane of commutation does not coincide with the geometrical north-south plane; and in searching for the cause he found that the degree of shifting was in a sense a function

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* Pogg. Ann., Bd. LXVII.

† Pogg. Ann., Bd. XC.

‡ Pogg. Ann., Bd. XLIV.

§ Pogg. Ann., Bd. LXI.

|| Pogg. Ann., Bd. XLVII and LXI.

of the current intensity; thus he recognized the existence of armature reaction.

Following the lead of Weber, he worked out with much thoroughness the relations for maximum current output for such machines; but perhaps the most important of all these later investigations was that series in which he studied the characteristics of the armature of the magneto-electric generator. As a result he was enabled to chart the sinusoidal electromotive wave form, the position and magnitude of a wave form due to counter-electromotive force, and the curve of magnetization as impressed and also as shifted by armature reaction.* In thus charting his data, he was one of the very earliest of the scientists who employed those graphical methods which are now so valuable and universally employed.

SWARTHMORE, PA., August 15, 1902.

THE BRUSH STORAGE-BATTERY PATENT EXPIRES.

The last barrier in the way of the general manufacture of electric-storage batteries was removed on March 3d by the expiration of the Brush patent on storage-battery electrodes. The *Electrical Review*, commenting on the fact, says that there may not be a great increase in the number of factories, but the magazine looks for improvement and extension of the use of power-batteries.

The electric motor-car manufacturers, it says, will profit more than anybody else by the new order of things. Lighter and better batteries for motor cars will appear, and the highly developed products of the European makers can be imported. In this way the prices can be reasonable, and the performance of electric motors greatly improved, with a resulting increase in their popularity and an augmenting business for manufacturers, both of machines and of batteries. Slight change is expected to occur in the power-station batteries.

The Brush patent, says the *Review*, was one of the most remarkable patents in the history of the electrical art. It covered completely the art of making plates by mechanically applied material, as a paste, powder, or in any other form. There have been repeated assaults on it in the Federal Courts, and enormous sums of money were spent in litigation to have the patent declared invalid, but in every instance it came forth victorious.

"To sum up," concludes the *Review*, "the result of the expiration of the Brush patent will be to improve and extend the use of power-batteries, though not markedly, and to increase greatly the quantity and quality of the cells for motor-car work."

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* Pogg. Ann., Bd. XLVII and LXI.

Annual Reports of the Schools of Drawing, Machine Design and Naval Architecture for the Sessions of 1902-1903.

THE DRAWING SCHOOL.—The season just closed has been the most successful one in the history of the drawing school, not only in the number of the students, but also in the regularity of their attendance and the earnestness of their purpose, and it is gratifying to realize the great benefit that they have received.

After this training in constructive drawing, they are able to perceive the relations between the lines and surfaces of solids, and this creates a desire to understand the mathematics of these relations and the scientific reasons why certain results follow certain combinations.

Hence the study of mechanical drawing stimulates an ambition for a scientific education, and paves the way for it in so far as it trains the mind to form tangible conceptions and to put these on paper in such manner as to be readily understood.

Another great good that the school is doing is in raising the standard of work. A good drawing can be made just as easily and as quickly as a poor one, if proper methods are used. The former is clear, quickly understood and read, and not apt to lead to errors. It is positive and absolute in all it says. The latter is just the reverse. Instead of being expensive, a good drawing is positively economical, because, if made by a properly trained man, its first cost need be no more than that of a bad one, and it saves in the time of those who have to work to it, and in the greater accuracy of the results attained.

The excellence of our course of instruction, and the good work done by the instructors, are best attested by the fact that the attendance at the spring term was only 6 per cent. less than at the winter term.

THE GERMANTOWN JUNCTION BRANCH SCHOOL.—Mr. H. G. Norbom, Director of the Branch School at Germantown Junction, transmits the following report of its operations:

The attendance at the Branch School in the past year has been better than ever before, and it is very gratifying to see that the leading manufacturers surrounding the school appreciate the advantages in sending their young men for instruction.

There has been a steady increase every year. The school started some years ago with about a dozen scholars, while during the past year there were ninety-five scholars on the roll.

The results that have been shown by the scholars in neatness, accuracy and knowledge has been very gratifying to the instructors connected with the school, and a number of the young men have been helped to secure good positions with engineering concerns.

We beg to extend thanks to all who in one way or another have helped to make the Branch School successful.

WM. H. THORNE,
Director.

THE FOLLOWING STUDENTS ARE ENTITLED TO HONORABLE MENTION:

In the Senior Mechanical Class.

Arthur C. Heintze,
Leonard Hoerle,
John McMonagle,
Joseph Schenkel,
Henry Stranahan, Jr.,
Harry W. Fox,
J. Warren Smith,
Howard W. Howitz,
John Heenan,
Henry S. Cowell,
Harry Hartranft,
George M. Norman,
J. Monroe Bowen,
James McGettigan,
Elmer B. Severs,
Frederick Thomas Uezzell,
Miles L. Tully,
Edmund H. Berry,
Clarence Helmbold Wilson.

In the Intermediate Mechanical Class.

Herman Fink,
Chester D. Thorpe,
Walter D. Williams,
William Wentzell,
George Moxley,
Henry G. Weaver,
Albert F. Heeley,
G. Hagstrom,
Emil H. Schulze,
Samuel H. Blittersdorf,
Albert Smith,
James W. Marriott,
George F. Kauffman,
Harry Stange,
Frank Roller,
Charles F. Pfeiffer.

In the Junior Mechanical Class.

Harry Wickland,
P. H. Erisman,
John Reilly,
C. W. Leeds, Jr.

In the Architectural Class.

Daniel Sharp,
James F. Bowen,
Harry Stull,
John T. Rowley.

In the Free Hand Class.

David Bowers,
William E. Talbot,
John Talbot,
Max J. Grocki.

THE FOLLOWING STUDENTS ARE AWARDED SCHOLARSHIPS FROM THE B. H. BARTOL FUND, ENTITLING THEM TO TICKETS FOR THE NEXT TERM:

Harry Wickland,
George L. Gillingham,
G. Hagstrom,
C. W. Leeds, Jr.,
Daniel Sharp,
David Bowers.

THE FOLLOWING STUDENTS HAVING ATTENDED A FULL COURSE OF FOUR TERMS, WITH SATISFACTORY RESULTS, ARE AWARDED CERTIFICATES:

Edmund S. Allen,
Edmund H. Berry,
James F. Bowen,
Harry Hartranft,
Leonard Hoerle,
John McMonagle,

George Blair,
Chris. Buckius,
Henry S. Cowell,
Jesse Croft,
Amos Fisler,
Harry W. Fox,
Frederick Froehlich,
Otto Guenther,
Louis T. Hall,
John Heenan,
Edward Hill,
Howard W. Howitz,
Walter Russell,
Henry Stranahan, Jr.,
J. Warren Smith,
William F. Spaeth,
Daniel Sharp,
Harry Stull,
Miles L. Tully,
Frederick Thomas Uezzell,
William Uhlhorn,
Clarence Helmbold Wilson,
Charles Wilson,
James J. Woods.

FROM THE BRANCH SCHOOL.

George Quinn,
J. Edward Lennon,
Herman Wilmunder,
Thomas Allison,
Harry M. Cox,
George Hutchby,
Edwin Wright,
Matthew S. Esch,
James Devlin, Jr.,
Harry Tennison,
Franklin S. Reinhold,
Richard Rigler,
Charles Reinhardt,
J. William Smith,
James P. Shaffer.

THE SCHOOL OF MACHINE DESIGN.—In point of numbers the condition of the school continues satisfactory, the registration this session being larger than ever before. The increase has been in the courses in mathematics, the technical courses, for which these are a preparation, showing a slight decrease.

Most of the students taking up the preparatory work are doing so with the object of qualifying for the more advanced courses; but it is our experience that many of these find the continued night work, after a day's labor, a too severe stress on their powers of endurance and are unable to continue. In consequence, the technical classes are largely made up of men who have obtained their mathematical training from outside sources, and this training frequently proves inadequate to properly carry on the work in hand. Our advanced classes have, therefore, always been small and are likely to continue so. Much diligence and great interest have been shown in all divisions of the course, and the students are to be congratulated on their persistent and painstaking efforts, which, judging from the progress made, cannot fail to be of lasting benefit to them and to reflect credit upon the school.

The class in algebra has been in charge of Mr. L. M. Arkley, and I am indebted to his care and skill for its prosperous condition.

LUCIEN E. PICOLET,
Director.

THE FOLLOWING HAVE COMPLETED THE FULL COURSE AND ARE AWARDED CERTIFICATES:

M. M. Borden,
W. J. Thompson,
J. C. Wobensmith.

THE FRANKLIN INSTITUTE SCHOOL OF NAVAL ARCHITECTURE.—I have the honor to report that the School of Naval Architecture has met with a substantial increase in its enrollment over last year, and that the average attendance of the senior division students during the winter term was 98 per cent., and for the spring term 98·6 per cent., the majority of this division making the full attendance; that of the junior division was 92·2 per cent. for the winter term and 91·6 per cent. for the spring term. Nine of the senior division have attended the full term of two years and, having passed the examinations, will be graduated.

The senior class in Practical Naval Architecture has studied the various details in construction of the different classes of vessels, making sketches and calculations for the same. In Theoretical Naval Architecture they have calculated weights of material, centers of gravity, strength of structure of the hull under varied conditions, trim, stability, etc. Their home work has shown wonderful energy, considering that the drawings, etc., are made without the usual adjuncts of a drawing office. In fact, this class has exhibited more than ordinary intelligence and its members are above the average, being neat and painstaking.

The junior students have progressed rapidly in both theoretical and practical naval architecture, and have also shown marked zeal in their work in class and at home. Numerous drawings beyond the average in neatness and accuracy have been made from blue-prints lent for that purpose.

The class is indebted to the following gentlemen for donating valuable prizes for attendance, home work and examinations: Mr. C. H. Cramp, President of the Wm. Cramp & Sons, shipbuilders and engineers, Philadelphia, Pa. Mr. Clement A. Griscom, President of the International Navigation Company, Philadelphia, Pa.; Mr. H. W. Morse, President of the New York Shipbuilding Company, Camden, N. J.; Mr. Lewis Nixon, President of the United States Shipbuilding Company, New York City.

Mr. C. H. Cramp has also offered a special prize to the apprentices employed by his firm who are students of this school and show marked efficiency in home work and examinations, as well as paying the fees of those who pass the examination at the end of each term.

ALEX. J. MACLEAN,
Director.

New York City, April 17, 1903.

THE FOLLOWING STUDENTS ARE AWARDED CERTIFICATES:

John Sutton,	J. Wilber Yeats,
Augustus Walko,	C. D. Wallach,
C. Chesley,	Harold Elfreth,
Sam'l H. MacDowell,	Lionel Levy,

Wassilly Wassilief.

Notes and Comments.

MOVING SIDEWALK SCHEME FOR NEW YORK.

The proposal made by Mr. Max Schmidt, of the Multiple Speed and Traction Company, to Bridge Commissioner Lindenthal is that the city should build the subway under the city from Bowling Green to the new East River Bridge at an estimated cost of $3,200,000, and lease it to the Multiple Company at a nominal rent, the company agreeing to operate a moving-platform transit system on the basis of a 1-cent fare. This proposition is now under consideration by the Rapid Transit Commissioner and pending his report no other proposition will be made.

Since the above proposition was made, a law has been pointed out by the Rapid Transit Commissioner, prohibiting the city from making any investment that does not guarantee a return of at least 4 per cent. This will doubtless cause a modification of the company's proposal as to the terms of the lease, but not as to who shall build the subway.

The company has full confidence in the success of the moving-platform system of transit, pointing to its success in other cities, and says it is willing to guarantee the city a return of 4 per cent. on its investment, but that it cannot do so on a 1-cent fare basis.—*Electrical World.*

ALUMINUM.

Messrs. Burgess and Hambuechen show the great influence which the ever-present, thin, invisible film on an aluminum surface has upon the success of various operations. The film is supposed to have considerable strength and continuity, and if it is broken or removed by mechanical means the aluminum immediately forms a new one. In soldering aluminum the principal difficulty seems to be due to the failure of the alloy used as a solder to adhere to the aluminum, a condition attributable to the protective film, which must be eliminated before the metals can unite. A successful solder consists of about 21 per cent. of zinc, 76 per cent. of tin and 3 per cent. of aluminum ; it may be applied directly to a cleaned aluminum surface without the use of a flux, and at a temperature but little above that which is necessary for soldering copper or iron. There are certain advantages in the apparent complication which the use of a flux involves ; a suitable solvent for the oxide film increases the rapidity of the soldering process, increases the certainty of adhesion and enables cheaper soldering mixtures to be used. The requirement for such a flux is that it should dissolve the coating and leave a clean surface for the solder to unite with, upon application of heat ; it seems that water cannot be a component of a suitable flux. A material which, for certain solders, forms an admirable flux, is stearic acid ; by applying it to a freshly scraped aluminum surface and then applying a tin-lead-zinc alloy, the matter of soldering aluminum presents scarcely greater difficulties than does the soldering of other metals. This almost ever-present coating upon aluminum is also the source of difficulty in the deposition of a permanent coating of other metals

upon aluminum surfaces; while it is very easy to deposit a layer of metal upon aluminum from almost any plating solution, in the great majority of operations the resulting coating can readily be removed, sometimes in remarkably thin and continuous layers. The prime requisite in successful depositions on aluminum is the complete removal of the protection film, so that the electro-deposited metal may be applied over the complete surface of and in intimate contact with the aluminum; if this condition is fulfilled, and the coating is non-porous, it will be durable. The converse of this operation, *i. e.*, the electro-deposition of aluminum upon other metals, appears to be impossible from aqueous solution. From the fact that, for equal weights, aluminum possesses about four times the energy as does zinc, considerable attention has been given to the problem of substituting aluminum for zinc in primary cells; but as a matter of fact, aluminum does not behave well as the electro-positive metal of a battery and attempts to use it in practice have almost universally failed. The results of measurements made by Mott, of the potential of aluminum in various electrolytes (measured against a normal electrode) are given in diagrams and tables. It appears that, of the various materials tested, ammonium fluoride would be the best material to use in connection with aluminum for battery purposes.—*Electrochem. Ind.*

THE MOND NICKEL PROCESS.

The success of the Mond nickel process, as carried on in England, has been seriously hindered by the discovery that the process is dangerous to the health of the men employed. During the summer there were over twenty cases of slight poisoning after a breakdown in the plant, and during the past month there have been three deaths from the same cause. The works are now shut down and both Dr. Mond and the company are sparing no expense in investigating the cause of these mishaps. Inquiries in the same direction are also being conducted by the English Government experts. It is stated that the symptoms are different from anything previously known to the medical profession, so that they are not likely to have been caused by the carbonic oxide employed. The source of danger is probably the volatile compound of nickel and carbonic oxide which is formed. There have been many difficulties encountered in the working out of this process and it is over ten years since the first experimental plant was erected. Doubtless, however, experience will eventually point out a way of operating with safety. Many successful metallurgical and chemical processes in their beginning have suffered from drawbacks.—*English Mining Journal.*

ELECTROLYTIC REFINING OF GOLD.

Dr. D. K. Tuttle gives an illustrated description in the January impression of *Electrochem. Industry* of the Wohlwill process of gold refining used at the Philadelphia United States Mint. The feature of the process is the electrolyte, which is composed of a gold trichloride solution, rather strongly impregnated with free hydrochloric acid; the latter addition is necessary, because if a gold anode be placed in a neutral or only slightly acid solution of gold chloride, gold will be deposited on the cathode, but little or no gold will be

dissolved from the anode, free chlorine being given off instead. The temperature of operation is 50° to 55° C., this increased temperature serving to reduce the voltage required, and at the same time to diminish the amount of free acid necessary to suppress evolution of chlorine at the anodes. Circulation of the electrolyte is also necessary. The cost of the hydrochloric acid required in the bath is 20 cents per 1,000 ounces of deposited gold. Any platinum present in the bullion can be recovered; it dissolves, but is not deposited with the gold. When the electrolyte becomes sufficiently charged with platinum, the gold is first precipitated by sulphur dioxide and reserved; then the platinum remaining in solution is separated as ammonium-platinum chloride; lastly the copper is recovered by passing the wash waters over iron scrap. He does not treat by this process bullion having a fineness of less than 940 gold.

INK FOR RUBBER STAMPS.

The vehicle used in the preparation of inks for rubber stamps is glycerin, a non-drying substance; so that pads charged with the color may remain usable indefinitely. Such ink, of course, is not as desirable as one that would thoroughly dry on exposure, but the latter—regular printing ink—requires a kind of handling too troublesome for most users of stamps.

Anilin colors are usually employed as the tinting agents.

The following is a typical formula, the product being a black ink:

Nigrosin	3 parts.
Water	15 "
Alcohol	15 "
Glycerin	70 "

Dissolve the nigrosin in the alcohol, add the glycerin previously mixed with the water, and rub well together.

Nigrosin is a term applied to several compounds of the same series which differ in solubility. In the place of these compounds it is probable that a mixture would answer to produce black as suggested by Hans Wilder for making writing ink. His formula for the mixture is:

Methyl violet	3 parts.
Bengal green	5 "
Bismarck green	4 "

A quantity of this mixture should be taken equivalent to the amount of nigrosin directed.

These colors are freely soluble in water, and yield a deep greenish black solution.

We have found the anilin compound known as brilliant green to answer in place of Bengal green.

As to the permanency of color of this or any anilin ink, no guarantee is offered. There are comparatively few coloring substances that can be considered permanent even in a qualified sense. Among these, charcoal takes a foremost place. Lampblack remains indefinitely unaltered. This, ground very finely with glycerin, would yield an ink which would perhaps prove

serviceable in stamping; but it would be liable to rub off to a greater extent than soluble colors which penetrate the paper more or less. Perhaps castor oil would prove a better vehicle for insoluble coloring matters.

Almost any anilin color may be substituted for nigrosin in the foregoing formula, and blue, green, red, purple, and other inks obtained.

Insoluble pigments might also be made to answer as suggested for lamp-black.—*Drug. Circ. and Chem. Gaz.*

A UNIQUE PLANING MACHINE.

A unique planing machine has recently been installed in the Washington Navy Yard for the purpose of finishing the surfaces of the propellers used in the tank in which models of warships are tested. The ponderous machine weighs 10 tons, while some of the propellers on which it operates weigh only 2 pounds each, their diameters varying from 5 inches to 2 feet. Although designed especially for planing helicoidal surfaces, there is a provision for planing irregular surfaces by means of cam-wheel attachments. The propellers planed may have two, three or four blades, may be either right or left-handed, and the blades may be all in one plane, or they may be tilted either forward or backward, not to exceed 10 degrees. The bronze castings are bolted to a circular table, which is given oscillatory motion about a vertical axis. Above the table, the setting for the tool-heads has an up-and-down movement, governed by the position of the fulcrum on a walking-beam. The feeds are automatic, and when all are thrown in, the four tool-heads and two cam-rollers work in unison.—*Iron Age.*

Book Notices.

Penrose's Pictorial Annual for 1902-03. An illustrated review of the graphic arts. New York: Tennant & Ward. 8vo. (Price, $1.50.)

The eighth volume of this interesting annual has just been issued. Much space is devoted to the various color-processes, and a number of excellent specimens of three- and four-color prints are shown. Process work is treated from the commercial as well as the artistic side, and the book is full of good examples of half-tones. There are 100 pages of reading matter and over 200 illustrations, printed on good paper and attractively bound. A. R.

Letters and Lettering. A treatise with 200 examples, by Frank Chouteau Brown. Boston: Bates & Guild. 1902. 8vo. (Price, $2.00.)

While the literature on this subject is already quite extensive, the present work is a welcome addition. It deals especially with classic and mediæval letters and their application to modern book-making. The work is exhaustive and contains considerable historical information; the illustrations are appropriate and numerous, and include, in addition to the standard forms of letters, medals, medallions, book-covers, posters, title-pages and tablets. The book will be most useful to artists and master printers. A. R.

Experiments with Vacuum Tubes. By Sir David L. Salomons, Bart., M.A. (With 54 illustrations.) 12mo, pp. vii + 79. London and New York: Whittaker & Co. Price, 2 shillings.)

The author presents in this booklet some new methods which he has devised for the study of the phenomena caused by the electric discharge in so-called vacuum tubes. He has observed that many of these phenomena are obscured or confused, and their correct interpretation rendered difficult if not impossible by reason of the employment of currents of very high E.M.F. and large currents. He accordingly employed in his study of the phenomena very small E.M.F. and very small current. By this method, he claims, the difficulties which beset earlier investigators disappear and the phenomena are seen in their purity. Then on raising the E.M.F., successive superadded phenomena appear, which would be extremely puzzling had the start not been made in this manner. Then follows a detailed account of numerous experiments under varying conditions with a great variety of tubes.

A second part of the book describes the author's observations on the effects produced upon electric discharges in rarefied gases when placed in the magnetic field. W.

Telephone Lines and methods of constructing them. By Walter C. Owen, Consulting Telephone Engineer, etc. (With 265 illustrations.) 12mo, pp. viii + 389. London and New York: Whittaker & Co. 1903. (Price, 5 shillings.)

This work deals exhaustively with the details of telephone line construction—overhead and underground—and is intended to afford telephone employees and others interested in the subject a general knowledge of the methods employed in various countries. The book is profusely illustrated and should prove a useful addition to telephone literature. W.

Chemical Technology, or chemistry in its application to arts and manufactures; with which is incorporated Richardson & Watts' Chemical Technology. Volume IV. Edited by W. J. Dibdin, F.I.C., F.C.S., etc. Electric Lighting, by A. G. Cooke, A.M., A.M.I.E.E.; Photometry, by W. J. Dibdin, F.I.C., F.C.S., etc. 4to, pp. xiii + 378. Philadelphia: P. Blakiston's Son & Co. 1903. (Price, $3.50 net.)

The volume above named forms Part IV of the well-known Chemical Technology of Groves & Thorp.

The aim of the authors, in which they have succeeded very satisfactorily, has been to present, in concise, connected and scientific order, the principles and important facts bearing on their respective themes, and to present their data in such manner as to be serviceable to all those to whom a general knowledge of the subjects considered would be of value. W.

Traité de Chimie Physique. Les Principes. Par Jean Perrin, Chargé du Cours de chimie a la faculté de sciences de Paris. 8vo, pp. xxvi + 300, avec 38 figures. Paris: Librarie Gauthier-Villars. 1903. (10 fcs., relié 13 fcs.)

This work appears to be a thoroughly modernized version of the principles of physical chemistry, the evolution of which in recent years has so materially modified our notions of chemical action. W.

Franklin Institute.

[*Proceedings of the Stated Meeting held Wednesday, April 15, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 15, 1903.

President JOHN BIRKINBINE in the chair.

Present, 44 members and visitors.

Additions to membership since last report, 14.

Mr. L. E. Levy presented the report of Mr. Lewis S. Ware, delegate of the Institute to the meeting of the Association of Inventors and Industrial Artists, held in Paris, December 11, 1902, to present a testimonial to M. Millerand, ex-Minister of Commerce. [The report was accepted with the thanks of the Institute. It is printed as an appendix to these minutes.]

In the absence of Mr. Marshall G. Moore, Mining Engineer, Cambria Steel Company, Mr. Birkinbine presented his paper on "The Explosion in the Rolling Mill Mine of the Cambria Steel Company," at Johnstown, Pa. This disastrous accident happened on July 10, 1902, and involved the loss of 112 human lives. The subsequent investigation of the case demonstrated beyond doubt that the explosion was caused by carelessness on the part of some one of the miners in using a naked light, in direct violation of stringent regulations to the contrary. [Mr. Moore's paper is referred for publication.]

Mr. Rufus J. Foster, of Scranton, Pa., followed with a paper giving a historical sketch of the origin and development of the Miners' Safety Lamp, illustrating the subject by the exhibition and description of a large number of these devices. The thanks of the meeting were tendered to Mr. Foster for his interesting communication.

Mr. Wilson L. Gill, of New Paltz, New York, read a paper describing "The School City." This is a system which Mr. Gill has devised for the training of the children in the schools in the practice of popular government. The system is in successful operation in many schools throughout the United States and in Cuba. The intention of the speaker is, if possible, to have the plan adopted in the public schools of Philadelphia.

Mr. L. E. Levy spoke in highly commendatory terms of the value of the system, and offered the following resolution, which was adopted:

Resolved, That the Franklin Institute recommends the system of "The School City," proposed by Mr Gill, to the consideration of the Committee on Science and the Arts.

Adjourned. WM. H. WAHL, *Secretary*.

REPORT

OF MR. LEWIS S. WARE, DELEGATE OF THE INSTITUTE TO THE MEETING OF THE ASSOCIATION OF INVENTORS IN PARIS, DECEMBER 11, 1902.

To the President and Members of the Franklin Institute.

GENTLEMEN:—In compliance with your wishes I acted as delegate of the Franklin Institute at a meeting held at the Arts et Métiers, Paris, on Decem-

ber 11, 1902, to present a memorial medal to M. Millerand, ex-Minister of Commerce, for services he had rendered to inventors of all countries who have occasion to examine French patents.

The question at issue was fully explained by Maitre Claude Couhin, the President of the Association of Inventors and Industrial Artists. Comparison was made between the exceptional facility offered in the United States, England and Germany for detailed examination of patents and all documents relating thereto. In France, on the other hand, there are numerous formalities to be contended with.

The expired patents were deposited in the Conservatoire des Arts et Métiers, while the others were in the building of the Ministry of Commerce. The demands for patents were made in another section of the city, and the money installments for patent applications was a formality that was carried out elsewhere. Through the exertions of M. Millerand the whole subject has been much simplified, and all patents, whether new or old, all demands, consultations, etc., may now be made at the Conservatoire des Arts et Métiers, Paris. The questions relating to the issuing of patents is at present entirely different from what it formerly was, for then several years would elapse before a new patent could be consulted in its printed and official form; only a certain number of these were ever issued *in extenso*. At present, all patents are to be published in full; their price is to be 1 franc, regardless of size. The Government appropriation for the printing was $60,000 per annum; but of the 13,000 patents granted only 6,500 were hitherto printed. At present the Imprimerie Nationale undertakes the printing of all the patents for the sum mentioned; this consequently means an annual saving to the French Government of $60,000. Another reform that has been instituted by the ex-Minister of Commerce is the question of annual dues on patents. Since 1844 it has been the custom to consider as canceled any patent upon which the inventor had not promptly paid a given sum at a specified date; but now a delay of three months is allowed and a nominal fine is demanded. There is yet another reform that was the outcome of M. Millerand's exceptional energy; this relates to the industrial artists. The hitherto existing laws were very contradictory; no one knew whether it was the rulings of 1793 or those of 1806 which were in vogue. The difficulty has been overcome through the law of 1902, by which creators of artistic models and design are protected under clauses readily understood.

Very truly,

LEWIS S. WARE.

Committee on Science and the Arts.

[*Abstract of proceedings of the stated meeting held Wednesday, April 1, 1903.*]

MR. CHAS. E. RONALDSON in the chair.

The following reports were adopted:

(No. 2219.) *Method and Apparatus for Storing Acetylene.*—Messrs. Claude, Hess and Fouché. (Applicant, Mr. John S. Seymour, New York.)

ABSTRACT.—The essential feature of this ingenious process and apparatus is the utilization of the great solubility of acetylene gas in acetone, for storing comparatively large quantities of the gas dissolved in acetone under pressure, the solvent being absorbed in a porous material such as asbestos or porous bricks, contained in a steel cylinder. A suitable reducing valve permits the gas to be drawn off and delivered to the burners at the proper pressure for giving the best illuminating effect. The report is reserved for publication in full.

For the novelty and utility of these inventions the John Scott Legacy Premium and Medal is recommended to the inventors. [*Sub-Committee.*—Dr. H. F. Keller, Chairman; Wm. McDevitt, Louis E. Levy, Dr. Wm. O. Griggs.]

(No. 2258.) *Multiple-Unit System of Electric Traction.*—Frank J. Sprague, New York.

ABSTRACT.—The system is covered by U. S. patents Nos. 660,065-6, October 16, 1900, and 696,880, April 1, 1902, granted to the applicant. The object is to permit the operation of electric railway trains made up of any number of units, and to enable the train to be rapidly accelerated and maintain the maximum tractive effort on the wheels. This is accomplished by making each unit a motor car and attaching a controlling cable to all controllers, so as to enable the various units to be combined in a train and operated by a single controller at each end of the train. (The technical details of the system will appear in the full publication of the report.)

In consideration of the important advance in the operation of electric roads which these inventions represent, the award of the Elliot Cresson Medal is made to the inventor. [*Sub-Committee.*—Wm. C. L. Eglin, Chairman; A. Falkenau, Clayton W. Pike.]

(No. 2260.) "*Hylo*" *Incandescent Electric Lamp.*—W. J. Phelps.

ABSTRACT.—As its name indicates, the lamp referred to is of the "turndown" kind. The report refers to the various plans devised to accomplish this in practice, viz.: (1) The combination of a rheostat and switch by which the lamp may be given varying brightness. (Introduced by the T.-H. Company.)

(2) The placing of a choke coil in the socket of incandescent lamps to be used on A. C. circuits, and by the aid of variable resistance and inductance, as a switch is turned the lamp is dimmed. (The Reis regulating socket.)

(3) A lamp in which two filaments are placed in series, and at the turn of a milled head at the side of the lamp-base placing them in parallel. (The Edison night lamp.)

(4) A two-filament lamp so connected that when placed in a special socket several combinations may be effected: (*a*) at first stop they are in series; (*b*) at second, one is short-circuited; (*c*) at third, both are put in parallel; (*d*) at fourth, the circuit is opened. (The tri-light lamp.)

(5) A lamp of two filaments: one of the kind regularly in use, and the other a very fine filament of moderate length, which, by a switching device, can be put in series with the other. When so arranged, the combined resistance is such that only enough current gets through to bring the *small* filament to incandescence, while the other is not even heated to a dull red.

The invention here referred to is of this last-described type, and appears to be the first of the kind to have proved commercially successful. Of the various patents issued to applicant for this invention, U. S. patent No. 603,705 appears to be the most important.

The report alludes to the general demand for a practical "turn-down" lamp in hospital wards hallways, bathrooms, bedrooms (especially in hotels) and similar places, and proceeds to give some comparisons of current consumption and candle-power between the normal filament and the fine one, and refers to the extremely long life of the latter (4,000 hours of continuous service).

The merits of this form of "turn-down" lamp are that it can be used with ordinary lamp sockets without special fixtures or wiring; that it shows very good economy; that in turning down, the circuit is not opened, nor any process gone through with that would involve the possibility of short-circuiting the series; and that the life of the small filament greatly exceeds that of the large one.

The award of the Certificate of Merit is made to the inventor. [*Sub-Committee.*—Arthur J. Rowland, Chairman; Thomas Spencer.]

(No. 2266) *The Kodak Developing Machine.*—Eastman Kodak Company, Rochester, N. Y.

ABSTRACT.—The apparatus is designed to enable the photographic operator to carry on the development of negatives without the aid of a dark-room and without any handling of the film whatever until it is developed and fixed. The report will be published in full.

The report concludes by recommending the award of the John Scott Legacy Premium and Medal to Arthur W. McCurdy, the inventor of the device, for the excellent performance and certainty of action of the apparatus and the ingenuity shown therein. [*Sub-Committee.*—Lucien E. Picolet, Chairman; Dr. Wm. O. Griggs, Urbana C. Wanner, Samuel Sartain.]

The following reports passed first reading:

(No. 2226.) *Label-Pasting Machine.*—Fred. W., Thomas V. and Walter Myers, New York and Philadelphia.

(An advisory report.)

(No. 2276.) *Process and Apparatus for Butter-Making.*—Chas. M. Taylor, Jr., Philadelphia.

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Sections.

(*Abstracts of Stated Meetings.*)

CHEMICAL SECTION.—Thursday, October 30, 1902. Dr. Henry Leffmann in the chair. Present, 38 members and visitors.

Prof. W. P. Mason, of Troy, N. Y., gave an informal address on "The Water Supply of Gibraltar," illustrated by a number of lantern photographs.

January 2, 1903. Mr. Lyman F. Kebler in the chair. Present, 32 members and visitors.

The paper of the evening was presented by Mr. Albert P. Sy, Frankford

Arsenal, Philadelphia. Subject: "The Stability of Nitrocellulose and Nitrocellulose Powders." Informal communications were presented by Drs. H. F. Keller and Henry Leffmann.

January 29th. Mr. Lyman F. Kebler in the chair. Present, 6 members.

Prof. Chas. E. Munroe, of Washington, D. C., read a paper on "The Methods of Making the Census of Manufactures in 1900."

The Executive Committee named Dr. Robt. H. Bradbury and Mr. W. E. Ridenour, to be president and secretary of the Section respectively, for the year 1903.

March 19th. Dr. Robert H. Bradbury in the chair. Present, 52 members and visitors.

Dr. Harry C. Jones, Johns Hopkins University, gave a lecture on the subject of "What Physical Chemistry has Done for Chemistry."

PHYSICAL SECTION.—November 6th. Prof. Geo. F. Stradling in the chair. Present, 18 members and visitors.

Dr. Louis A. Bauer, of Washington, D. C., read the paper of the evening on "Terrestrial Magnetism."

January 15, 1903. Dr. Henry Leffmann in the chair. Present, 26 members and visitors.

Dr. Leffmann presented an illustrated communication on "The Development of Modern Ideas as to the Form and Position of the Earth." Prof. Luigi d'Auria read a paper on "A Relation between the Mean Speed of Stellar Motion and the Velocity of Wave Propagation in a Universal Gaseous Medium, Bearing on the Nature of the Ether."

ELECTRICAL SECTION.—November 13th. President Thomas Spencer in the chair. Present, 32 members and visitors.

Mr. Leonard B. Marks, of New York, presented a paper "On the History of the Development of the Enclosed Arc Lamp." Mr. Rulon, of Philadelphia, described and exhibited an improved form of primary battery.

January 8, 1903. Mr. Thomas Spencer in the chair. Present, 46 members and visitors.

The paper of the evening was read by Messrs. C. C. Rosenberg and H. S. Balliet, of Bethlehem, Pa., on the subject of "Automatic Electric Railway Signaling," which was profusely illustrated with lantern photographs.

February 12th. President Thomas Spencer in the chair. Present, 69 members and visitors.

Mr. W. J. Hammer, of New York, read a communication entitled "Notes on Recent Electrical and Scientific Developments Abroad." The subject was fully illustrated.

The Executive Committee named the present officers to serve for the year 1903.

March 7th. President Thomas Spencer in the chair. Present, 32 members and visitors.

Mr. C. E. Farrington, of Boston, read a paper on "Defective Machine Insulation."

MINING AND METALLURGICAL SECTION.—November 20th. Mr. Alex. E. Outerbridge, Jr., in the chair. Present, 43 members and visitors.

The communication of the evening was presented by Mr. Albert Sauveur, of Boston, on "Metallography," which was fully illustrated with the aid of apparatus, experiments and diagrams. The subject was discussed by Messrs. Paul Kreuzpointner, Robt. Job, W. R. Webster, the chairman and the author.

December 18th. Mr. James Christie in the chair. Present, 64 members and visitors.

The papers of the evening were as follows: "Coal Handling," by Mr. F. V. Hetzel; and "Ore Handling," by Mr. A. C. Johnston, of Philadelphia. The speakers illustrated their remarks by the exhibition of numerous lantern views.

February 5, 1903. Dr. Wahl in the chair. Present, 13 members and visitors.

Mr. E. F. Morse, of Trumansburg, N. Y., exhibited and described his new electrical pyrometer, called a "Heat Gauge," for the accurate measurement of high temperatures.

March 5th. Dr. E. Goldschmidt in the chair. Present, 56 members and visitors.

Mr. Howard W. Dubois, of Philadelphia, gave an account of "Observations Made During a Recent Mining Reconnoissance in the Rockies of British Columbia." The speaker illustrated his remarks with the aid of a number of extremely fine lantern photographs.

Stated Meeting, April 2d. Dr. E. Goldschmidt in the chair. Present, 54 members and visitors.

The Executive Committee announced the appointment of the following to serve as officers of the Section for the current year, viz.: President, James Christie; Vice-Presidents, Prof. F. L. Garrison and Wm. R. Webster; Secretary, G. H. Clamer; Conservator, Dr. Wahl.

The paper of the evening was presented by Mr. Clamer. Subject: "The Study of Alloys Suitable for Bearing Purposes." The author illustrated his remarks with the aid of a large number of photomicrographs and tables. The discussion which followed was participated in by Messrs. Paul Kreuzpointner, A. E. Outerbridge, Jr., Robert Job and the author. (Paper and discussion will appear in the *Journal*.)

G. H. Clamer,
Secretary.

Section of Photography and Microscopy.—*Twenty-first Stated Meeting*, Dec. 11th. Dr. Leffmann in the chair. Present, 40 members and visitors.

Mr. Janson, representing the Eastman Kodak Company, gave a description and made a demonstration with a new developing machine dispensing with the use of the dark-room.

Dr. Leffmann and Mr. U. C. Wanner gave some account of a number of new photographic chemicals sent for exhibition by the Farbenfabriken von Elberfeld Company. The subject was illustrated by the exhibition of specimens of the products, photographic prints, lantern pictures, etc.

February 14, 1903 Dr. Leffmann in the chair. Present, 15 members and visitors.

Mr. John Bartlett presented a communication (read by the Chairman) on "Under- and Over-exposures." The subject was freely discussed.

Mr. M. I. Wilbert made some remarks in connection with several lantern views representing an improved induction coil made by the Heinze Electrical Company, of Boston.

Dr. Leffmann exhibited several lantern photographs of ancient and recent maps, and commented upon the subject.

Twenty-second Stated Meeting, April 4th. Dr. Henry Leffmann in the chair. Present, 48 members and visitors.

Dr. Leffmann and Mr. F. A. Keely presented a joint contribution on Agar-agar. Dr. Leffmann gave an account of the origin and uses of the plant, and Mr. Keely described and exhibited under the microscope the characteristic forms of diatoms found therein by which it can be identified when used as a substitute for gelatin.

Mr. U. C. Wanner presented a communication on "Some Experiments in Stand or Tank Development," which was illustrated by the exhibition of a number of negatives and prints made from negatives developed in tanks with dilute developer.

Mr. Martin I. Wilbert addressed the meeting on "The Use of Lantern Slides as an Aid in Object Teaching." The speaker illustrated the subject by showing a number of slides (loaned by Prof. Jos. P. Remington) exhibiting botanic and pharmacologic objects colored by students of the St. Louis College of Pharmacy.

Mr. Howard W. DuBois exhibited a number of artistically colored slides and made some remarks on the method of coloring.

Dr. Leffmann exhibited a number of slides representing typical desert vegetation.

M. I. WILBERT,
Secretary.

MECHANICAL AND ENGINEERING SECTION.—January 22, 1903. Mr. Jas. Christie in the chair. Present, 54 members and visitors.

Mr. Kern Dodge, of Philadelphia, read a communication entitled "Notes of Observations on Power-Cranes," with numerous lantern illustrations.

Mr. Ernest M. White, of Philadelphia, described an improved and much simplified "compound engine" of his design.

February 5th. Dr. E. Goldschmidt in the chair. Present, 23 members and visitors.

Mr. Carl Barth, of Swarthmore, Pa., addressed the meeting on "Slide-rules in the Machine Shop as Part of the Taylor System of Management."

Stated Meeting, April 16th. Mr. James Christie in the chair. Present, 34 members and visitors.

Mr. Hoadley, representing the Waterbury Tool Company, exhibited and described a new mechanical movement, consisting of a flexible joint for shafting, so designed as to transmit motion when the angle between the two sections of shafting is as much as 60°.

Mr. J. F. Rowland, Jr., then opened the discussion of the subject of Fuel Oil, which was participated in by Messrs. Lovekin, Parker, Wurtz, Eppelshimer and the chairman.

D. EPPELSHIMER, JR.,
Secretary.

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JOURNAL

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THE FRANKLIN INSTITUTE.

On the Present Status of the X-Rays.*

BY M. I. WILBERT.

A short seven years ago the newspapers of the country were publishing lengthy accounts of physical experiments, that were being carried on by scientific investigators all over the civilized world. These experiments were being made with a view of proving, or disproving, if possible, the assertion of a German professor of physics, that he had made a wonderful discovery, and that he was able, by means of certain well-known physical apparatus, to take photographs of objects that were invisible to the human eye.

How slow the civilized world was to grasp or appreciate the possibilities contained in the original contribution, is evidenced by the fact that it was nearly a calendar month after Professor Roentgen announced his discovery before

* A lecture delivered before the Franklin Institute and the Central Branch Young Men's Christian Association, in Association Hall, Philadelphia, Friday, February 13, 1903.

the Physico-Medical Association of Würzburg, before any news of the same reached this country, and it was fully three weeks more before sufficient of the details were available to permit American physicists making experiments along the same lines.

Many of you will remember how, after the publication of additional reports of success, excitement and expectation ran high, the wildest and most wonderful assertions were made as to what this new form of energy really was or what it might be expected to do. A collection of newspaper clippings of the early months of 1896 would be interesting reading at the present time.

It must not be supposed for a moment that this discovery was entirely an accidental one, or made by a man whose mind had not been trained to make observations along particular lines of scientific research.

Wilhelm Conrad Roentgen was, at the time he discovered the X-rays, 50 years of age, and by far the greater number of these years had been devoted to the study of physical phenomena. In consideration of his abilities and scientific worth he had been made professor of physics at Giessen, in 1879. It will be remembered that this is the university at which the celebrated Liebig did his world-renowned work in chemistry. From Giessen, Roentgen was transferred to Würzburg in 1888, having acted as assistant here to Professor Kundt, in the early seventies. It was in the Physical Institute of the University of Würzburg, while at work on a subject that had been more or less actively discussed for upwards of eighty years, that Professor Roentgen noted that a piece of paper, coated with platinum barium cyanide fluoresced, when a vacuum tube, which he had wrapped in black or opaque paper, was excited by means of a suitable electric current. The direct cause of this particular experiment dates back to 1816, when the English philosopher and scientist, Michael Faraday, in one of his lectures, suggested that matter probably existed in a fourth state, in which it had properties as different from a gas as this is from a liquid, or a liquid from a solid. Matter in this supposed fourth state was designated by Faraday as radiant matter.

A discussion of the subsequent investigations and the controversies that arose from them would take us too far from the subject immediately before us. Suffice it to say that, following along lines of thought suggested by Faraday, a number of noted scientists have made experiments and propounded theories. In Germany, Professor Plücker, of Bonn, was able to induce the ingenious mechanician, Heinrich Geissler, to devote a considerable amount of time to the construction of those ingenious pieces of the glass-blower's art so well known to all of you as Geissler tubes.

Professor Hittorf and, somewhat later, Professor Goldstein, worked along the same lines, and it was the latter who propounded the theory that the phenomena observed when a current of electricity was passing through a vacuum tube was due to vibratory motion in the ether.

The English physicist, Mr., now Sir William Crookes, was able to construct and use tubes of very high vacuum, with which he appeared at least to be able to demonstrate that the visible phenomena was due to the movement of material particles, thus actually demonstrating Faraday's supposed fourth state of matter.

The lecture or demonstration embodying Crookes' investigations was given in connection with the annual meeting of the British Association for the Advancement of Science, at Sheffield, in 1879. In the course of this lecture Crookes failed to mention the work done along the same lines by German scientists, particularly Hittorf and Goldstein, and it was this omission, probably more than the difference in theory advanced, that caused a revival of interest in the subject in Germany.

Among others, Prof. Heinrich Herz, of Bonn, devoted considerable time to the study of the phenomena accompanying the discharge of high potential electric currents through vacuum tubes. After his death the subject was continued by his assistant and pupil, Paul Lenard; the work done by the latter investigator practically leading up to where it was taken up by Roentgen, who, while repeating and elaborating on Lenard's experiments, discovered the very interesting physical phenomena, the practical application of which we are to review this evening.

As noted before, Roentgen's attention was attracted by the fluorescence of a piece of paper coated with barium platinum cyanide. His trained mind was not slow in grasping the possibilities of this phenomena, and these he demonstrated by subsequent experiments.

It may be interesting to add here that so complete were Roentgen's researches and experiments, that comparatively little of practical importance has been added since Roentgen read his first paper. The practical application of the X-rays has been largely restricted to medicine and surgery; but in this field their usefulness has fully come up to, if not exceeded, the expectations of the early experimenters. It is true that the crudeness of the early apparatus and the careless way in which many of the early experiments were conducted brought failure, and with failure discredit and suspicion of a method so little understood, and apparently so fraught with possible dangers.

To get some idea of the improvements that have been made in apparatus and methods of technique, let us first look at these two pictures of a purse. The first was made by Professor Goodspeed, of the University of Pennsylvania, in February, 1896, and was one of the first X-ray pictures made in this city. It required an exposure of thirty minutes at a distance of 10 centimeters (about 4 inches) from the tube. The second picture, made recently, required an exposure of but three seconds, with the tube 50 centimeters, or about 20 inches, from the object.

In addition to the very decided decrease in the time of exposure, we have in the latter picture a very marked increase in detail and penetration. The two coins in the purse are sharply outlined, the seams of the leather are clearly indicated, and, in addition to this, there is sufficient penetration of the metallic objects to show the contour of the silver through the brass coin. The reasons for this improvement will be more appreciated when we come to consider the source of the X-rays.

So far as known, X-rays are produced only by the discharge of a high potential electric current in a vacuum-tube. To get the most efficient rays, however, it is necessary that the tube be of special construction.

The most satisfactory tubes available at the present time are those in which the cathode rays are focussed to impinge on a comparatively small portion of a platinum plate forming the anode. This plate then becomes the source of the X-rays.

In the early tubes the cathode rays impinged on the glass wall of the tube directly opposite to the cathode. The whole area on which the cathode rays impinged became the source of X-rays, thus distributing their origin over a large surface, thereby causing a more or less blurred image on the photographic plate or fluorescent screen.

The source of the electric energy is of considerable importance. Broadly speaking, we have two possible sources of supply—the older and perhaps less efficient generator, and the more modern and now widely used transformer.

The generator type is best represented in the well-known static machine, the forerunner of which was invented by an early German scientist, Otto Von Guericke, more than 250 years ago; it was later improved upon by Sir Isaac Newton, who substituted a glass globe for the sphere of sulphur used by Von Guericke.

The present type of influence machine was invented almost simultaneously by Holtz and Toepler, in 1864, while a modification of it was introduced by Wimshurst, and is usually referred to by that name. Static machines, as used at the present time, may be said to consist of two or more glass plates so arranged that we have alternately a stationary plate carrying the so-called armature, and a revolving plate in front of which are the combs or brushes to collect the electricity when the machine is set in motion.

This, however, while it is no doubt the simplest form of generator for an electric current of high potential, is not so uniformly reliable as is the transformer.

With the transformer we must of course have some other source of electric energy; this may be the simplest form of primary battery, or we can use the current direct, or modified in several ways, from the ordinary street-lighting plants, the latter of course being much the more economical where any appreciable quantity of current is to be used.

The type of transformer that has been used with most satisfactory results is represented by the well-known Ruhmkorff or Ritchie coils. Here, again, we cannot stop to go into details as to the construction or the comparative efficiency of different modifications of this well-known piece of physical apparatus; suffice it to say that while even the best available coil cannot be considered the acme of perfection, these coils must, at the present time at least, be considered to be the most reliable and altogether the most satisfactory source of high potential electric energy available. In addition to the Ruhmkorff type of coil, what is variously known as a Tesla, Thompson or high-frequency coil, has been used to some extent in connection with X-ray work. This type of coil, while it is perhaps more efficient as a transformer, does not give as satisfactory results in connection with the high-vacuum tube.

Among other forms or modifications of older transformers we may mention the Kinraide coil; this is practically a double induction coil; Thompson's static transformer, this being essentially a combination of Leyden jars, and Professor Trowbridge's ingenious combination of storage batteries, with which he has been able to duplicate any and all of the results obtainable with an induction coil.

We said a few moments ago that the only available source of the X-rays was by means of a discharge of a high potential electric current through a vacuum tube; this statement should be qualified by saying that this is the only practicable source of the X-rays. Early in 1896, when all sorts and kinds of experiments were being conducted with a view of finding other sources of the X-rays, Monsieur Henri Becquerel discovered that several chemical substances had the property of affecting photographic plates through opaque wrappers. A number of scientists have taken up this particular line of investigations, and the results obtained so far appear to indicate that this field offers some most interesting possibilities. Madame and Monsieur Curie have devoted considerable time to the study of what is usually referred to as radio-active matter, and they have been able to isolate several supposedly new

elements, one of which, at least, appears to have been established as a distinct and separate element. This is radium, which has just been added to the list of elements by the International Commission on atomic weights. It has been given the symbol Ra, and is supposed to have an atomic weight of approximately 225. In addition to radium, there are two other radio-active elements—polonium and actinium; while, in addition, both thorium and uranium appear to have radio-active properties.

We have this evening several pictures that were made by means of the Becquerel rays. (All of the rays produced by these various radio-active bodies are usually referred to as Becquerel rays.) These pictures were made by placing a quantity of urananite in a paper envelope, wrapping a photographic plate in several layers of opaque paper, and then placing several metallic objects between the envelope containing the urananite and the package containing the photographic plate, and allowing them to remain in contact in a dark-room for from one to ten or twelve hours. On developing the photographic plate it will be found that an image of the denser objects interposed is quite sharply defined.

So far, these Becquerel rays have attracted little attention outside the realm of pure science; and while the possibilities of their application are numerous, the scarcity and comparative high price of strongly radio-active materials has prevented any extensive experiments being made in their practical application.

A possible use for the X-rays that suggested itself at an early date was their application in time of war to locate bullets and other missiles, and in this way dispense with the ofttimes dangerous practice of probing.

These rays have been used, with very satisfactory results, in no less than four campaigns: the British Soudan campaign, the Græco-Turkish war, the American war with Spain, and also in the British-Boer war in South Africa.

In the war with Spain the X-rays were used quite extensively and with very satisfactory results. In this connection it may be mentioned that military surgeons usually ascribe a marked proportion of the decided decrease in the mortality of the injured to the judicious use of the X-rays.

The medical department of the United States Army has recently issued a very complete and exhaustive report on "The Use of the Roentgen-Ray by the Medical Department of the United States Army in the War with Spain, 1898."

The data for this report was compiled by Captain, now Major, W. C. Borden, who has charge of the X-ray work in the army hospitals.

The contained half-tone plates and pictures are particularly interesting, as illustrating the variety or kind of an injury made by the modern small-arm projectile.

Wars, while becoming more dangerous, are fortunately becoming more and more expensive and less plentiful. There are, however, quite a number and variety of accidents that are of daily occurrence and to which the X-rays are important as an additional means for determining the nature as well as the extent of the resulting injury. We cannot expect to go over the list of possible fractures, so must content ourselves with indicating just a few of those occurring most frequently, and incidentally pointing out to you several points in which injuries of this kind differ from the accounts or descriptions of them found in the older text-books on surgery.

There is a widespread popular belief that a sprain is worse than a fracture or break. The fundamental reason for this belief is illustrated by a number of pictures that we have here, which show that what is usually called a sprain is ofttimes a fracture involving one or more of the bones at or near a joint. These joint fractures usually do not involve any appreciable amount of the articulating surface of a bone, and are therefore not readily recognized as fractures by the ordinary methods, consequently are not treated as they should be. It does not require much medical knowledge to appreciate that an injury to a bone at or near a joint, not properly treated, may lead up to very considerable interference with the normal function or use of that joint. Among the portions of the body that are particularly susceptible to injuries of this kind are the wrist, elbow, shoulder and ankle; in each of these the X-rays have demonstrated fractures that formerly were not even suspected.

The proper treatment of injuries of this kind is, of course, made practically simple and easy by the accuracy and the completeness of the diagnosis. In addition to being useful as an additional means for diagnosis, the X-rays are also useful to control or to observe the progress of the subsequent treatment. After a fracture has been reduced, or set, as it is sometimes called, and the proper dressings applied, the X-rays may be used to see the exact position of the bones, whether or not they are in apposition, and whether or not the dressings have been properly applied.

The only kind of surgical dressing that interferes materially with an examination of this kind is one in which a metallic splint is used. The ordinary wooden splint, or even a plaster-of-paris cast, does not interfere materially with the penetrating properties of the X-rays.

That there is even with the X-rays a possibility of making an error cannot be denied; this possible error is however entirely due to the personal factor that necessarily enters into the making of an examination of this kind. With increased experience on the part of the X-ray operator, or possibly with the introduction of improved apparatus that will do away with the necessity of close personal attention, this possible source of error will be largely if not entirely eliminated. The X-rays themselves being a purely mechanical problem, with fixed and definite factors, the results obtained must necessarily represent the sum total of these various factors. We must pass on, however, to the consideration of other possible uses for the X-rays.

Dislocations or luxations are not always so readily recognized as one would be led to suppose. There are quite a number, partial luxations particularly, that are not easily recognized in the ordinary way, or that are sometimes mistaken for an injury or lesion of quite a different character.

We have here a number of pictures that illustrate the difficulty of making a diagnosis of a luxation, or especially of a partial luxation. If any further evidence were needed, it might be found in the newspaper reports of the clinics given by the celebrated Austrian orthopedic surgeon, Dr. Lorenz, who, when on his visit to this country, operated on

quite a number of luxations, particularly congenital luxations of the hip joint.

These congenital luxations are so persistent and difficult of treatment, simply because they are not recognized early enough. The injury, usually occurring at the time of birth, is not recognized until the child begins to try to walk. By this time the muscles and tendons have adapted themselves to the new position of the thigh bone, the normal articulation has been partially obliterated and a new or false articulation has been formed. To overcome this combination at this late day requires an operation of considerable extent, and operative skill of a very high degree; whereas, if the lesion had been recognized in time a comparatively simple procedure would have accomplished the same purpose.

Foreign bodies, particularly when they are of a substance denser than the portion of the human body in which they are imbedded, are readily recognized.

In the extremities they are easily located by taking X-ray pictures in two different directions. In the flat portions of the body this is not done so readily, and for locating foreign bodies in the third dimension, several very ingenious and more or less successful methods have been adopted. In England pictures of this kind are quite frequently taken stereoscopically; by mounting the resulting negatives so that they may be looked at in a reflecting stereoscope, a very fair idea of the depth at which the body is imbedded may be had. Another method that depends on pretty much the same principle is that followed by Mr. Mackenzie Davidson. This consists of taking two pictures of the same part from two different angles, and then, by a very simple method of triangulation, locating exactly the depth at which the foreign body is located.

Dr. William M. Sweet, of this city, has devised a very ingenious little apparatus that was designed to locate foreign bodies in the eye, but is also applicable to other portions of the body, particularly the hands and feet.

The location of foreign bodies in the gastrointestinal tract is of very great importance. Quite a number of deaths have been reported, due to injury caused by unrec-

ognized or unsuspected metallic bodies in different portions of the body.

Accidents of this kind are not at all infrequent, particularly with children, who appear to have a morbid fancy for swallowing all sorts and kinds of metallic substances, such as coins, pins and small toys. How readily these ingested foreign bodies may be located is illustrated in a series of pictures that we have here showing foreign bodies in the esophagus, the stomach and also in different portions of the intestinal canal.

The treatment of these cases is simplified and may be closely followed and controlled by means of the X-rays. Usually a foreign body will pass through the intestinal tract without doing any material damage. There are, however, cases where prompt surgical interference is indicated, and for these the X-rays are of very great use and importance, in that we are able definitely to locate the foreign body, get a very fair idea of its comparative size, and from this data judge of its probable injurious action.

Ingested foreign bodies are not as painful or as dangerous as are the collections or accretions of materials that are sometimes formed in the different abdominal organs.

The gall-bladder, the kidneys and also the bladder are frequently affected in this way. Of the three, calculi or stones in the kidneys are most difficult to recognize by the ordinary methods. The X-rays make a diagnosis of stone in the kidney a matter of comparative simplicity, particularly in the hands of an experienced or careful operator. Dr. Charles Lester Leonard, of this city, has done much original work in this particular line, and has contributed materially to establish the X-ray method of diagnosing renal calculi.

From the kidneys these calculi occasionally find their way down through the little tubes, called ureters, to the bladder. While passing through the ureter they may be the cause of intense pain; at times they are so large that they completely occlude the ureter and become firmly lodged. In cases of this kind surgical interference becomes necessary, and here again the X-rays are of value in locating the site of the

occlusion, and in this way indicating the most desirable course for operation.

In the bladder, a kidney stone may become the nucleus for a larger stone or calculi; this may go on accumulating material for years before it interferes enough with the normal function of the organ to occasion pain or discomfort. It must be remembered, however, that a kidney stone is not necessary to occasion a stone in the bladder; a number of other causes may produce the same results.

In more purely medical cases the X-rays are quite extensively used to recognize or to demonstrate pathological conditions of several of the internal organs. For examinations of this kind, where the size, location and action of the different organs is to be studied, the fluoroscope is perhaps more valuable than is the photographic plate, as by means of the former the actions and movements of the different internal organs can be observed and a considerable amount of additional information gleaned in this way.

In case a pathological lesion has been observed by means of the fluoroscope, and a permanent record of the same appears desirable, a radiograph or X-ray negative may be made. This forms then a permanent record for future reference or comparison.

In the practice of dentistry the X-rays are of value. By means of them the process of dentition may be studied as it has never been observed before, as any irregularities or abnormal features are readily recognized. In addition to this, however, even the structure of the individual teeth may be demonstrated, and in case of abscess-cavities these may be recognized and positively located.

The nature and kind of work that has been done by the dentist can also be demonstrated or shown; and in case of an accident, such as the breaking of a drill in the root of a tooth, the foreign body is readily shown and located. In extraction cases the presence or absence of a fracture of the alveolar process may be determined if thought desirable.

In chemistry, particularly in detecting adulterations of inorganic materials in drugs or chemicals of organic origin, the X-rays have been used to considerable extent and have

quite a wide field of application. Drugs like the gums, gum resins, and resins, that are rather difficult to examine in the ordinary way, are readily examined for inorganic or earthy adulterations by means of these rays. In coal, asphalt and other materials of a like character, the amount as well as the distribution of the ash or inorganic material may be determined very readily.

For the study of human, or for comparative anatomy, the X-rays offer advantages not found in any other direction.

The osseous structure of any of the vertebrates may be pictured so as to show the size, structure and relative positions of any and all of the bones composing it. In addition to this, the development of the bones may be studied at different stages in the same animal or individual, and in this way a very complete study of the formation and gradual development of the osseous structure may be made and accurately recorded. The complete anatomical structure, of the smaller animals particularly, is at times rather difficult to get at. By means of the X-rays not alone one, but a number of small animals, may be examined, so that the normal structure of the animal may be decided on with a considerable degree of accuracy.

Even the conchologist can make use of the X-rays for the study of the shape, structure and composition of shells, particularly of such as are rare or difficult to get, and which he does not care to submit to dissection.

All of these recounted uses, however important as they may appear, become comparatively insignificant when compared to the possible uses of the X-rays as a therapeutic agent.

Not long after the discovery of the X-rays by Roentgen, it was noted that after a prolonged, or even after repeated short exposures of any portion of the body to the energy emanating from a vacuum tube, peculiar secondary effects sometimes manifested themselves; these secondary effects varied from a slight tanning or reddening of the skin, simulating sunburn, to the production of a deep burn or ulcer. It was not long before experiments were being made with a view of controlling these secondary effects, and to develop,

if possible, their curative properties. It was argued that if these rays have the property of changing healthy cells, they should also have the property of bringing about a corresponding change in degenerate or diseased cells.

During the past four or five years a large number of more or less authenticated or reliable reports have been published, and at the present time the X-rays have firmly established themselves as having marked curative properties.

So far as known, the X-rays are applicable in but a limited number of diseases, and even here there appear to be isolated cases, where, for some unknown reasons, the X-rays do not act as promptly and as satisfactorily as in others. The reasons for this are no doubt to be found in the fact that medical men have not as yet been able to demonstrate the underlying causes, or the action of the X-rays on the various pathological conditions. A considerable amount of work is, however, being done in this direction, and it is to be expected that in the near future physicians will be able to say why and how this particular form of energy brings about changes in pathological conditions, and also be able to say in which particular conditions the X-rays will be of use as a therapeutic measure.

Until such time as physicians have some definite knowledge as to the limitations and possibilities of the X-rays, it will be well to be conservative in their use, with a view of avoiding any injurious after-effects from possible abuse.

In summing up the present applications and uses of the X-rays, it will be safe to say that as an additional means for making a complete and satisfactory diagnosis, in a variety of medical as well as surgical affections, this new form of energy has more than come up to the expectations of those most interested, and bids fair to be even more satisfactory in the immediate future.

For technical or applied scientific purposes they have probably not developed along the lines in which it was at first expected they might find application; but even here they have found uses, and these uses are constantly increasing.

As a therapeutic measure for the relief of suffering and

the cure of a number of chronic and usually discouraging conditions, they bid fair to eclipse in usefulness and applicability any one curative agent that has been added to the armamentarium of the physician for a decade at least.

No attempt has been made here to even indicate the effect that the discovery of these rays has had, both directly as well as indirectly, on purely scientific theories or investigations. Suffice it to say that they have materially broadened the horizon of positive scientific knowledge, and have in some cases shattered theories that were considered well-nigh unassailable.

In conclusion, just a few words as to the man to whose acumen, scientific training and pioneer work on the borderland of the great unknown we are indebted for much of that meager knowledge that we possess of the X-rays at the present time.

Wilhelm Conrad Roentgen was born on March 27, 1845. After the usual preliminary education he attended lectures at Utrecht and later at Zurich, where he obtained his doctor's degree in 1869. He appears to have been a favorite student with Professor Kundt, and the following year, when that professor assumed the chair of Physics at Würzburg, young Roentgen went with him as his assistant. In 1873 Roentgen went with Kundt to the University of Strasburg. Two years later he was made lecturer on mathematics and physics at the Agricultural Academy .in Hohenheim. The following year he was back at Strasburg, and in 1879 he was made professor of physics and director of the physical institute at Giessen.

From here Roentgen was transferred to the University of Würzburg in 1888, where, on November 8, 1895, he made the discovery that has made his name familiar throughout the civilized world. After the announcement of this discovery he was knighted by the King of Bavaria, who also offered him the professorship of physics in the University of Munich, which he now holds.

Roentgen has received recognition, medals and honorary memberships from scientific societies all over the world.

Among the acknowledgments of a more practical nature

that he has been the recipient of, it may be well to say that in 1901 he was awarded the Nobel prize instituted by the late Alfred Bernhard Nobel, the inventor of dynamite, for the most important invention in the domain of physical science.

Altogether it may be said that the active life of Professor Roentgen has been one of close application to the exacting details of his chosen branch of science, and the merited recognition he has received for making what appears to be indisputably his discovery but illustrates that the world, after all, is quite willing to reward patient, honest workers who are willing and able to demonstrate that they are capable of doing something that no one else has done before.

STEAM TURBINE INSTALLATION.

A unique steam turbine installation is about to be made at the Cumberland Mills, Portland, Me. Most of the current for the present electric drive is supplied by a water-power plant, and the balance by a steam-power plant. The new steam turbine will be used for relay purposes, trouble being sometimes experienced with the water-power system, due to irregularity of water-supply. The turbine is 540 horse-power, taking steam at 165 pounds pressure, after it has traversed the distance of 350 feet separating the boiler-house from the engine-house. Before entering the turbine the steam will be superheated about 100° F. by means of an independent superheater, fired by waste hydrogen gas rising from electrolytic baths used in the process of manufacturing at this plant. The gas has heretofore been a waste by product. The steam "economy" will be about 13·5 pounds per electrical horse-power hour, which means about 11 pounds per indicated horse-power hour.—*Iron Age.*

FRENCH LAW OF EMPLOYER AND EMPLOYEE.

A law still obtains in France, under which any workman who divulges information regarding a secret process practised in any industry, to a foreigner, or even to a Frenchman resident abroad, commits a penal offense, and for such is liable to a sentence ranging from two to five years' imprisonment and a fine from $100 to $4,000. He is furthermore subjected to from five to ten years' police supervision after his release from jail. Even the communication of such information to another Frenchman resident in France is punishable though the sentence in this case is not so severe, the sentence varying from three months' to five years' imprisonment, accompanied by a fine ranging from $3 to $40. On the other hand, a French employer is entitled, without reserve, to any invention or discovery made by a workman in his employ that is within the scope of the work undertaken at the factory —*Scientific American.*

About Some Important Polar Navigations to High Latitudes.*

By Dr. Arnaldo Faustini.†
Translated from the Italian by Edwin Swift Balch.

The question of an open polar sea dates back to long before our time.

It occupied the thoughts of the oldest cosmographers, philosophers and mathematicians, especially those of the

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* Published in "In Giro pel mondo," II, Bologna, August and Sept., 1900.

† Dr. Faustini, of Rome, is the author of a number of valuable papers about the Arctic and the Antarctic. Among them may be cited :

Sugli approdi alle regioni polari antartiche.—"Rivista Marittima," 1898.

Alcune altre osservazioni sulle "appearances of land" nella zona polare antartica.—"Bolletino della Societa Geografica Italiana," 1898.

Esplorazione dell' oceano Australe, Viaggio del Valdivia.—"Rivista Marittima," 1899.

Risultati generali della spedizione antartica Belga.—"Bolletino della Societa Geografica Italiana," 1900.

Il ritorno della spedizione polare di S. A. R. Il Duca degli Abruzzi.—"Societa Geografica Italiana," 1900.

L'Italia e le prossimi spedizioni polari Antartiche.—"Rivista politica e letteraria," 1900.

Alcune osservazioni sulla crociera dell Hertha.—"Bolletino della Societa Geografica Italiana," 1900.

Alcune considerazioni sulla meteorologia delle regioni antartici.—"Rivista Marittima," 1901.

Un tipo caratteristico di ghiacciaio antartico.—"Rivista di Fisica, Matematica e Scienze Naturali," 1901.

Di una scoperta polare australe nel 1599.—"Rivista di Fisica, Matematica e Scienze Naturali," 1901.

La Groenlandia del Sud.—"Bolletino della Societa Geografica Italiana," 1901.

Una Questione Artica.—"Rivista Italo-Americana," 1902.

Un Viaggio alle Spitsbergen nell Anno 1671.—"Rivista di Fisica, Matematica e Scienze Naturali," 1902.

I primi resultati della spedizione antartica svedese.—"Rivista Marittima," 1902.

I risultati scientifici della spedizione antartica belga.—"Rivista Marittima," 1902.

La Groenlandia.—"Rivista Italo-Americana," 1902.

Alcune Idee religiosi degli Eschimesi, Rome, 1903.

Sulle Ultima spedizioni polari artiche.—"Rivista Marittima," 1903.

—(*Translator.*)

seventeenth and eighteenth centuries, who, with an infinite number of original and fantastic theories for and against it, acknowledged or denied its existence, according to the accounts which the whale fishermen gave when they returned to their native lands with valuable cargoes which fetched big prices.

However, the theory of a perfectly open sea was that accepted by the majority, as the accounts that the mariners gave had all the appearance of being true (the reader will not forget that in the past centuries the accomplishment of great enterprises gave to many persons an authority in speaking), and for certain facts, which could not then be explained, people were rather inclined to accept as valid and to believe the queer and fervid accounts about the mysteries of the northern regions, just as to-day the descriptions of Parry and of Nansen carry an inexplicable and eerie fascination.

Moreover, not only were people in those times thoroughly alive about the problem of the existence or the non-existence of an open sea at the pole, but there was also the desire to find and to see the pivotal point of the terrestrial axis, as well as to verify how much truth and exactness there was in the unbridled conceptions of the most ancient cosmographers and philosophers.

I have said that some facts, then unexplainable, tended to back up the theory of a vast icy ocean occupying the extreme northern zone of our planet. Some Dutch fishermen had seen and caught whales, which undoubtedly had been harpooned near Davis Strait, in the regions of Spitsbergen; and Paul Egede, the bishop and the last and greatest missionary of the Danish settlement in Greenland, relates, among other things, that in 1785 a dead whale was found floating in the waters of Baffin Bay bearing in its side a harpoon stuck there two days before in the neighborhood of Spitsbergen by the brother of the whaler who picked up the dead animal. Again, Witzen writes that a mariner of Zealand, Benedictus Klerk by name, whom he knew personally, related to him how he had killed whales on the eastern coast of Korea with harpoons stuck in their sides,

showing that they had been chased by Dutch fishermen in the North Atlantic. These, and still other facts, discredited considerably in those times the theory of a sea eternally closed with ice, and, on the contrary, gave weight to the opposite opinion. Neither party, however, knew then of the great and wonderful marine circulation, due to the not less wonderful currents, powerful rivers of the sea, which, from the day of their discovery, solved a considerable number of physical, dynamic and meteorological problems.

That which to-day would be explained and which was explained by many facts depending on the submarine currents over which the ice has no power, at that time was accounted for by the theory of an open sea, with wave and tide movements similar to those of the Mediterranean, the Atlantic and other known surrounding seas. Everyone knows the theory, which has become axiomatic, that permitted Dr. Nansen to accomplish fairly successfully his last great polar exploration on the Fram, giving himself up entirely to the mercy of the current which was surmised to cross the north polar regions, at least within a few degrees of the pole, and which revealed its existence by having carried objects and relics belonging to the unfortunate Jeannette of the American expedition (sunk in the neighborhood of the New Siberian Islands) to the western coast of Greenland, near Julianeshab.

One can credit with certainty to Gerard Mercator the priority of conception of a polar sea, or rather polar abyss, which the geographer Jacques Knoyen, of Bois le Duc, was the second to describe in a strange and fabulous narrative. The critic Raemdonck, in writing about the life and the works of the celebrated German geographer, adds that nothing more fantastic was written in medieval times about the polar regions, although by a letter of Mercator himself to Johann Balak, another illustrious geographer of those times, dated from Arusburgi ad Osselam fluvium, 20 Februaris, 1581 (that was after he had left Louvain and Duisburg in the province of Clèves), we learn that the study of the polar regions had occupied him actively and deeply during the greater part of his scientific career. In fact, we

owe to Mercator a strenuous and pertinacious defense of the existence of a northeast passage, for in one of his letters to Hakluyt we find that he says: "Beyond the Islands of Waigatz and of Novaya Zemlia there is a large gulf, which has on the east the famous promontory of Tobin (perhaps the cape and peninsula of Taimir), and near it large rivers empty which must undoubtedly irrigate the interior of Cathay and Sericana, and by means of which one can enter into those countries. This gulf freezes early each year."

Moreover, Mercator wondered whether in those places the tide always came in from the same side or whether it came in sometimes from another, whether it rose or descended six hours towards the east and six hours towards the west, and finally he put definitely, resolutely an end to the question of the possible separation between Asia and America (at the time when Abraham Ortelius doubted still whether America was surrounded by water or whether it formed at the northern extremity a single and vast continent with Asia) by marking on his chart a strait which he called Anian, a strait which, from a theoretical conception, became a known fact in 1648, at the time when the Cossack Deshneff saw the Arctic and Pacific Oceans mingle.

However, the theory of an open sea remained still in a rather indefinite condition and was accepted only by a few geographers and their disciples, and it was not until the year 1614—precisely the year in which, under the wise direction of a certain Wilhelm Van Muyden, the so-called Company of the North was founded in Holland—that these legendary tales became widely spread among the public and that it became necessary to give credence to the bold narrations of the wonderful expeditions to the north of the mariners, and especially of the Dutch mariners, which they told on their return from the annual seal and whale fisheries.

In the petition presented by the members of the Company of the North, Belgians, Biscayans, Flemish, English, etc., to the Government of the States General, they gave rather clearly the proof of the existence of the open sea which some of those very members of the Company had cruised on, saying:

"A number of vessels have visited regions where no Christians have been before us; they have passed 83° of north latitude, where these ships always had around them an open sea, free from ice and from pasture lands." (*Met eene quantiteit schepen alwaar nooit christen mensch outrent hadt gewest; ja dat zy hadden gepasseerd 83 graden alwaar haare schepen geronden hadden eene ruyne zee, zonder ys, vlak weidland met graseetende gedierte.*)

Many years after, that is in 1660, a few log books were presented to the Government of the States General by the same Company of the North (whose palmy days were on the wane; their brightest period was from 1614 to 1641), with the object of arousing the interest of the Government anew, and these were in accord in affirming that on August 1, 1635, observations were taken in 86° 56′ north latitude of an open sea and a very strong tide.

We have in chronological order:

1610: The first indication of an aim towards the Arctic pole appears in 1610, four years before the Dutch presented, as we have seen, to the Government of the States General their petition for the foundation of a company for the monopoly of the whale fisheries, when there were rumors of ships being pushed beyond the 83d parallel. In 1617, the congregation of whalers to the north of Spitsbergen was so great that it was necessary to erect a factory, the factory of Smeeremburg [Blubbertown], to serve as a station for provisions and for supplies that might be needed by mariners and their ships during the fishing season. The colony and the ship-station were established on the eastern coast of Amsterdam Island (a little north of Danes Island, the site of the tragic departure of the engineer Andrée) in 75° 45′ north latitude, and in a short time it became so important that, as the chronicle of that time relates, "the bakers announced that, as in their mother country Holland, customers could be furnished with bread just out from the oven."

In 1634 (that is the year after the failure of the attempt to colonize in the North on a large scale, conceived by a certain Jean Seghers of Bruges) the number of Dutch ves-

sels occupied in those regions in whale fishing was enormous. They numbered more than 500 ships, with over 20,000 men, and Zorgdrager relates about 120 Hamburg ships which captured in one season 1,252 whales that were sold for about 500 pounds sterling apiece.*

In 1636: It was in this year, as is related by Forster,† that "a ship was dispatched [from Holland] to Greenland for the purpose of fetching train-oil, which used to be manufactured in *Sewerenberge* [Smeeremburg]; but there being not a sufficient quantity ready to complete the full lading, the captain, finding the sea quite open, sailed strait [*sic*] on to the northward, and at the distance of two degrees from it [the pole?] went twice round it. This he used to relate publicly, and to refer to his crew as witnesses of the fact. Vid. Zorgdrager's *Greenland Whale-Fishery* (German), Vol. II, chap. 10, page 162. Wood also, as he himself informs us, was told by Mr. *Joseph Moxon*, in 1676, that being in Holland about twenty years before (consequently in 1656), he had heard a very respectable Dutch captain of a ship say that he had navigated under the very pole, where he found the weather as warm as it used to be at Amsterdam in summer."

Whoever wants further particulars regarding this voyage can find them in the collection of important marine undertakings of Harris, Vol. II.

1656: In this year another Dutch ship claims to have reached 89° north latitude. "In fine, Captain Goulden likewise, who had made upwards of twenty voyages to Greenland, told King Charles the Second that, being about twenty years before in Greenland,‡ he found himself with two Dutch Greenland navigators near Eges Island, to the east-

* "Pesca alla balena al Groenland," Vol. II. (In German.)

† Forster, John Reinhold: "History of the Voyages and Discoveries Made in the North." Dublin, MDCCCLXXXVI.

‡ Let the reader bear in mind that the Arctic geography and cartography of the seventeenth century makes no distinction between Greenland and Spitsbergen, since these two lands were believed to be one and to be united across the polar cap to the north of America, in about the position of the Parry Islands.

ward of that country, when, no whales appearing near the shore, the two Dutch captains resolved to sail farther on towards the north, which in fact they did, and a fortnight afterwards returned, and related that they had been as far as the 89th degree, and had met with no ice, but with a free and open sea, with large and hollow waves, as in the Bay of Biscay. The variation of the compass there was 5 degrees. One of these captains afterwards happened to go to England, when Captain Gould [*sic*] took him to some of the members of the Northern Company, whom he fully convinced of the truth of his relation. Vide *An Account of Several Late Voyages and Discoveries.* London, 1711, p. 145; as also *The Hon. Mr. Boyle's History of Cold.*"* We have an argument in defense of this rather mythical subject by G. Gauthier, general inspector of foreign affairs in Italy, in a note of his directed to the Manager of the "Biblioteca of Milan" (relating to an account written in January, 1828, about the voyages of Parry), in which he tries to vindicate the claims of some sailors who have gone much beyond the latitude reached by Parry himself (82° 45′). Gauthier, who bases his letter upon notes taken from Forster, concludes that he knows that the narratives of the mariners have been much embellished, but that he could not consider assertions as wholly inaccurate when they seem to him so circumstantial and so positive.†

1660: According to Carlo Amoretti, who illustrated and commented upon the voyage of Lorenzo Ferrer Maldonado,‡ a certain Captain David "Melguer is said to have left Japan with his ship *Lo Padre Eterno* on the 16th of March, 1660, and to have sailed along the coast of Tartary, till he came to the 84th deg. of N. lat., and then to have shaped his course between Spitsbergen and Old Greenland, and so

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* Forster, John Reinhold: "History of the Voyages," etc., page 427. Daines Barrington, in "The Possibility of Approaching the North Pole," page 37, gives an almost similar account.

† *Bulletin Soc. de Géographie de Paris*, January, 1828.

‡ "Voyage de la Mer Atlantique à l'Océan Pacifique par le N. O. dans la Mer Glaciale," par le Capt. Laurent Ferrer Maldonado, etc., Plaisance, Del Maino, 1812.

sailing to the west of Scotland and Ireland, to have at last entered the harbour of Oporto." *

1754: Daines Barrington, author of a history of Arctic voyages, writes, on the testimony of the schoolmaster, John Adams, of Essex, that a certain Captain Guy from that country, who reached, on board of the whaler Unicorn, the 83d degree of north latitude, on his last but one journey (his fifty-eighth) some months before, had reached the 84th degree.

1766: Dr. Hamel, also the author of some important works, asserts, on the other hand, that the nearest point to the pole undoubtedly reached up to his time, was the one attained by Captain James Bisbrown, who started from Liverpool in 1765 and who arrived at 83° 40′ of north latitude with a still open sea; whilst at the same time Barrington writes that Captain Wheatley had surpassed Bisbrown in 1675 by about 5° 30′.†

* Forster, John Reinhold: "History of the Voyages," etc., pages 464, 465. Forster continues, however: "This is the most material part of this relation, which, however, deserves no credit; for since the years 1637 and 1638, the Portuguese and Spaniards have been absolutely banished from Japan and that forever. How then was it possible for a Portuguese ship, twenty-two years after that period, to sail from Japan, a place where this nation was no longer admitted nor suffered? This consideration alone is sufficient to prove that the whole account is a mere rumor, and a story trumped up by some sailors, devoid even of the least shadow of probability arising from internal evidence."—(*Translator.*)

† In "The Possibility of Approaching the North Pole," Barrington says Jonathan Wheatley's highest latitude was 81° 30′. On page 61, Barrington gives the following list of latitudes reached by navigators:

"Captain John Reed, 80° 45′.

"Captain Thomas Robinson (for three weeks together), 81°.

"Captain John Phillips, 81° odd min.

"James Hutton, Jonathan Wheatley, Thomas Robinson, John Clarke (four instances), 81° 30′.

"Captain Cheyne and Thew (two instances), 82°.

"Cluny and David Boyd (two instances), 82° odd min.

"Mr. George Ware, 82° 15′.

"Mr. John Adams and Mr James Montgomery (two instance), 83°.

"Mr. James Watt, Lieutenant in the Royal Navy, 83° 30′.

"Five ships in company with Hans Derrick, 86°.

"Captain Johnson and Dr. Dallie (two instances; to which, perhaps, may be added Captain Monson, as a third), 88°.

"Relation of the two Dutch masters to Captain Goulden, 89°.

"Dutch relation to Mr. Grey, 89° 30′."—(*Translator.*)

1775: The Hollander Cornelis Rule is supposed to have reached a spot between 84° 30′ and 85° north latitude, where he discovered an archipelago, along which he sailed for ten miles, and beyond which he found a vast extent of open sea, so that if he had not been short of provisions he could have sailed several degrees more towards the north.

1786: The above cited Carlo Amoretti writes again that a certain Wiarth had reached the 89th degree of north latitude, where he found land and an active volcano.

1816: In the *Bulletin de la Société de Géographie de Paris* (October, 1827), one reads that in the year 1816 the whaler Neptune reached 83° 20′ of north latitude.

In an account given in the *Literary Gazette* of London (1825), it is stated that an English whaler, towards the end of the year 1824, approached the pole to within less than 1°, and discovered a coast where there were geysers of hot water in action, at some of whose rims there were flames sufficiently intense to ignite paper.

A last fantastic instance *sui generis*, occurred in 1894, and the matter was circulated in newspapers all over the world, arousing an immense amount of speculation and conjecture. This was that the American whaler Newport had reached in an open sea the 84th parallel of north latitude. Prof. George Davidson, however, not only interviewed the commander of the fortunate ship, but examined the log book, and he was able to deny the erroneous report which circulated for some time. The error arose in transmission, since instead of writing 73° and odd minutes of north latitude, 84° of north latitude was written.

Moreover, these are not the only instances which could be cited; there are many others.

Dr. Dallie gave a report of a ship which reached 88° north latitude. Mr. Miller, in his "Gardener's Dictionary," wrote about a Captain Johnson having, during a voyage to Greenland, a thermometer which registered "a degree of cold in 88° of north latitude."* Read relates that the Dutch

* See Daines Barrington: "The Possibility of Approaching the North Pole Asserted," New York, 1818, pages 44–46. Barrington makes here what appears to be an unintelligible attempt to explain an absurdity, namely, that

Captain Hans Derrick, during a whaling cruise in company with five other ships of the same nationality, undoubtedly reached 86° in a sea only slightly covered with pieces of floating ice. Finally, Buffon himself, in his "Natural History," basing his conclusions on the authority of Dr. Hickmann, member of the Royal Society in 1730, asserts that the voyage narrated by Captain Moxon is true.

And now we continue:

There may be something true and exact in the accounts given by the whaling captains of the marvelous voyages made in the waters of the extreme north.

We cannot vouch for the authenticity of the facts; but, at any rate, one of the greatest geographers of our time, Petermann, has written that the Dutch traditions of these polar expeditions (at which Admiral Osborn laughs, ridiculing them as the result of Amsterdam dreaming, backed up by strong Dutch beer) are to be accepted in more than one respect.

We return to our point, observing that such traditions—especially the first ones—were handed down verbally to our ancestors from mariner to mariner, from Dutch fisherman to Russian fisherman, from Russian fisherman to Norwegian fisherman, and so on, and that among all those stories there were only some which were reliable, and that the best of these were collected and published by some of the chroniclers and the scholars of the time, who sought in this way to confirm the theory of the open sea. And it is an error, if one may use the term, of the illustrious Gotha geographer to have too strenuously defended his opinions about the existence of a polar sea free from ice, founding his belief partly on the medieval legends of these navigations to high latitudes, where, we say again, the sea, the holy sea, as Muller* calls it, was said to have a wave and tide movement like that of the Bay of Biscay, and where the air was said to be so balmy that one might imagine one's self in Amsterdam during the summer season.

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because a thermometer marked a certain degree of cold, therefore the navigator must have reached 88° of north latitude.—(*Translator.*)

* "Sammlung Russischer Geschichten," Vol. III, chap. i.

And if one remembers that the number of Dutch, Hamburg, Bremen, Biscayan and Norwegian vessels sent to fish for whales between 1614 and 1750 was enormous, and that among the hundreds and hundreds of captains and shipmasters there may have been a few of easy conscience who did not mind drawing the long bow on their return home, it seems possible that some of their contemporaries may have doubted their accounts. It is easier to-day, in the strong and searching light of modern criticism, to sift the exaggerations from these tales and to account for the fantastic conceptions which gave birth to the ideas of an austral land and of a northwest passage which sprang from voyages such as those reported of Bernarda and of Lorenzo Ferrero Maldonado that l'Amoretti so warmly and so blindly defended.

Moreover, there is evidence of the strongest kind which helps us in forming an opinion, and that is, that these accounts would indicate a physical condition of the polar regions exactly the reverse of that which the more exact and thoughtful observations of modern navigators have shown existed. And even granting that the fascination of the marvelous had no influence on the minds of those mariners of long ago, and even admitting also that those sailors knew how to use the instruments which had been entrusted to them by the company to which they belonged, yet one can still reasonably suppose that they may have made mistakes in their calculations about the positions they thought they had reached, the more readily that the nautical and astronomical sciences of that time were very imperfect and left much to be desired.

On this matter, also, I think it opportune to quote what Malte-Brun writes in his learned introduction to the splendid collection of the "Nouvelles Annales des Voyages":

"It is easy to understand how mariners may in good faith think that they are in higher latitudes than they have really reached. Let one think of the extreme irregularity of all the movements of the magnetic needle in those seas; let one consider that one of the magnetic poles of the world may be placed so that at 80° of latitude the needle points

straight *to the south;* let one remember also the small geometric value of each degree of longitude, the convergence of the meridians, the extreme difficulty of observing the distances of the circumpolar stars, supposing that one is sailing straight ahead; let one reflect on the oblique position of the sun, if one sails by day; let one add to it the still little known effects of horizontal refraction; and one will probably admit that beyond the 80th degree even an expert sailor would have much difficulty in knowing precisely where his ship was. What then would be the situation of the navigator who had arrived under the pole itself?

"The ordinary indices of the art of navigation would be wanting for him to guide himself by; all the points of the world would be equally *to the south* for him; nothing would teach him how to make his way either to the east or to the west; the first steps, on whichever side he made them, would be done at hap-hazard; in a word, he might come back from the pole without knowing exactly if he had been there. Let one judge, then, of the amount of credence to be attached to those masters of whaling ships, who pretend to have sailed around the pole or to have been 2° beyond the pole!" *

As the reader can see—to make use of an expression not at all scientific, but very much to the point—the illustrious father of French geographers takes the bull by the horns and simply settles the question.

And now, when one brings together these four coefficients: the epoch, the fascination of the marvelous, the ignorance in the use of instruments, and the imperfection of the instruments themselves, one can and one must admit that some of the relations of journeys to very high Arctic latitudes, like the ones cited as examples, are vulnerable in almost every respect, and that, as Gauthier and Petermann write, even if there is some truth and accuracy about the stories, yet that they are too marvelous to bear close inspection.

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* Coup d'œil sur les découvertes géographiques qui restent à faire, etc.: "Nouvelles Anna'es des Voyages," Paris, Tome I, 1819.

Sulphur-Dioxide and the Binary Engine.*

By R. H. Thurston.

The "binary-vapor heat-engine," in its latest form, as illustrated by the machine employed at the Charlottenburg *Hoch Schule*, exhibits more clearly the advantages of the system than has any such apparatus previously reported upon, and the record produced under most satisfactory conditions is lower than was ever before known in the history of the economics of the heat-engines. Its consumption of steam, as a minimum, is reported as 8·36 pounds per horse-power-hour, 3·8 kilograms of moderately superheated steam, less than 9,500 B.T.U., or about 2,380 calories.† The power obtained was increased above one-third by the addition of this secondary system to the steam-engine and the economy was improved about 25 per cent. A gain of 20 per cent. was effected by the employment of superheated steam. The primary was a steam-engine of excellent construction and performance, having a "water-rate" of but about 11 pounds. These circumstances make it necessary to look upon the series-vapor engine much more seriously than has been customary. Such unquestionable economical advance must be carefully studied to ascertain whether the system can be made a commercially successful competitor of the common forms of heat-engine.

One of the first steps in such an examination of the case is the investigation of the scientific features of the system and the determination of the thermodynamic properties of the secondary fluid. As to the first of these questions there is no difficulty. The fact that the reduction of the lower limit of temperature of the heat-engine cycle is of more promise than an equal variation in the opposite direction at

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* Presented to Section B, A.A.A.S., Washington Meeting, 1902.

† "Series-Vapor and Heat-Waste Engines," *Jour. Frank. Inst.*, R. H. T., October–December, 1902.

the upper limit was shown by Carnot, who asserted, seventy-five years ago, that

"*La chute du calorique produit plus de puissance motrice dans les degrès inférieurs que dans les degrès supérieurs.*" *

The second question, that regarding the relations of pressures, volumes and temperatures of the fluid, at the comparatively low temperatures of the exhaust-steam and the condenser, is settled by experience already had in the practical operation of the secondary engine employing the vapor. It gives high-working pressures at the temperatures at which it receives and discharges heat within the low and narrow range permitted its cycle when employed thus as a secondary. Steam at these lower ranges, while perfectly capable of providing 30 per cent. more power than is actually obtained from it in ordinary constructions, yields that power at so low an absolute pressure and at such a small mean pressure that it is quite unavailable in so cumbersome a machine as would be needed to develop it. It would require so large a proportion of its work to actuate the engine itself that its power-product would not be profitable. With the high mean pressures of the sulphur-dioxide vapor, the power developed is available in paying quantities.

The question whether it will be practically possible to continuously employ this system as a commercial and profitable improvement upon the single-vapor engine must be settled by long experience under a great variety of conditions in regular business. The risks involved in handling the vapor, the wastes and costs of fluid, the disagreeables and the inconveniences, must all be more or less thoroughly evaded and extinguished. It is claimed that this has been accomplished. We shall know with certainty in due time.

The thermodynamic properties of the substance have not been fully investigated, and it will be interesting to ascertain just what advantage, if any, this substance has

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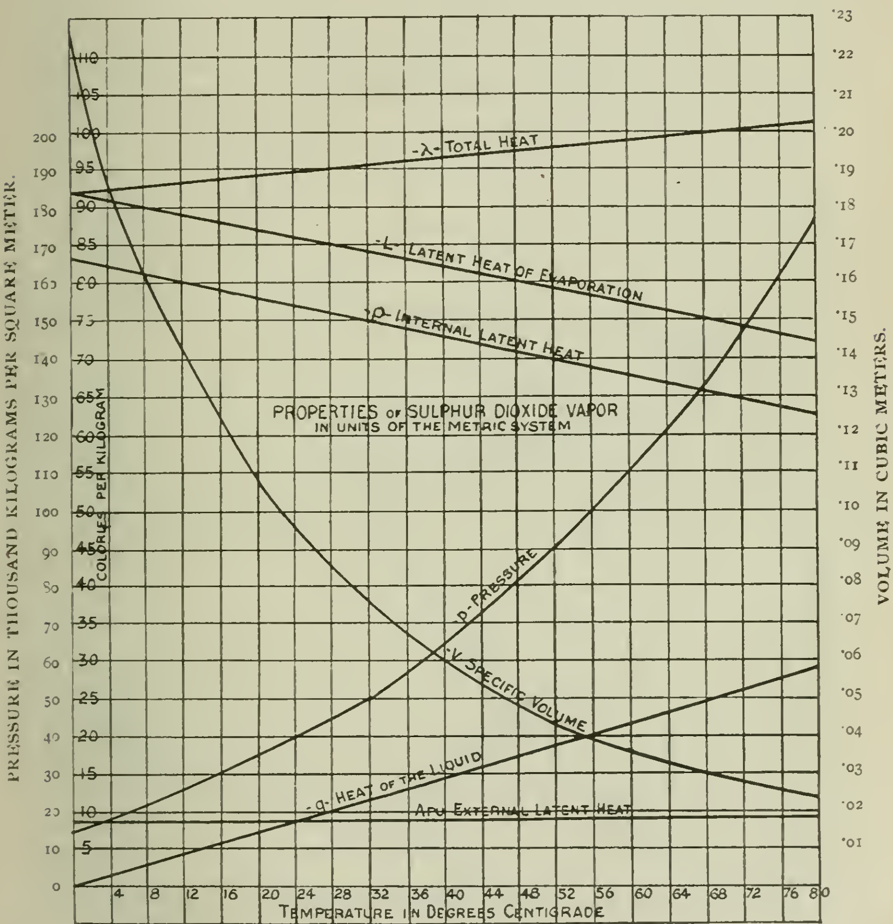
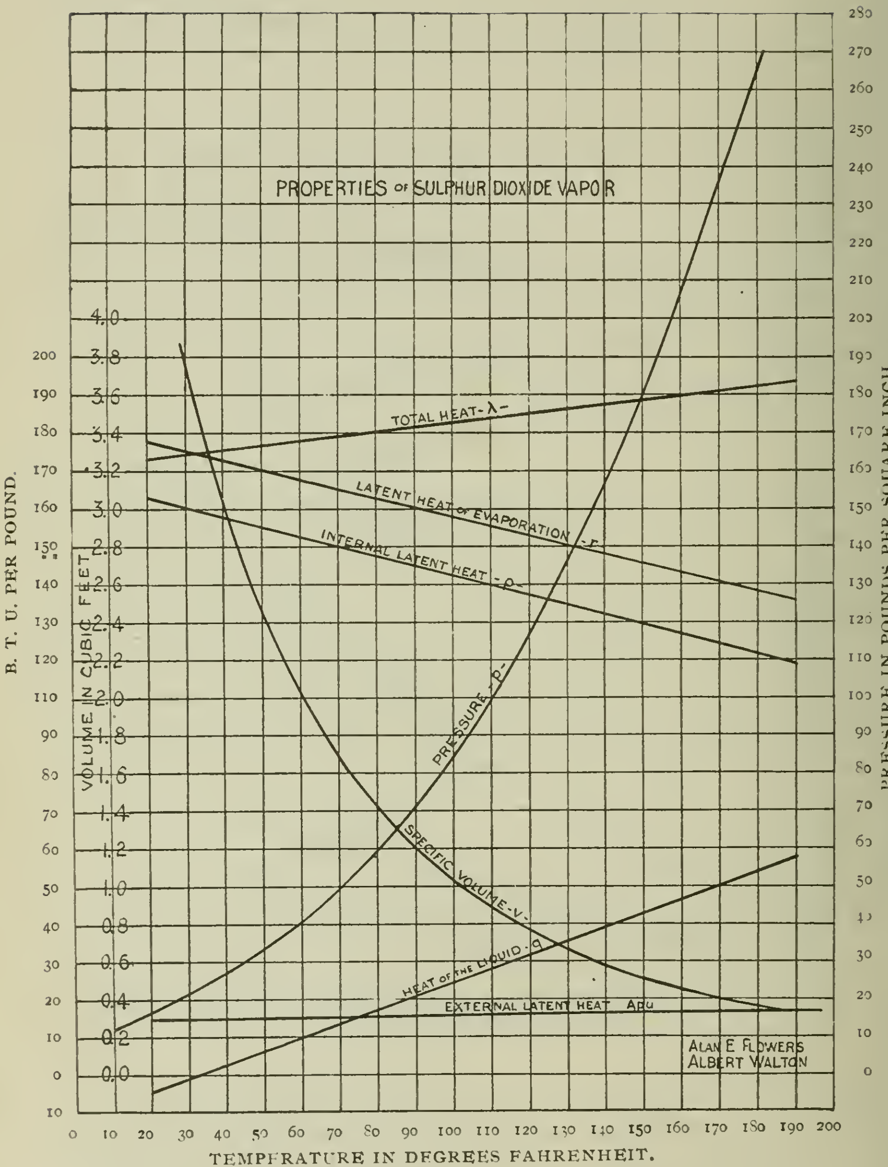
* "Réflexions sur la Puissance motrice du Feu." Paris: Gauthier-Villars, 1878.

"Reflections on the Motive Power of Heat and on Machines Fitted to Develop that Power." By N. L. S. Carnot. Thurston's translation. New York: J. Wiley & Sons, 1890.

over steam and other available working fluids. The adaptation of its pressure-volume relations to the prescribed temperature-range has been seen to be exceptionally perfect. The quantity of work which it may store in, and the suscepti-



bility of the substance to heat-exchange with, the metal of the working cylinder are yet to be determined; although the indications seem to be that, in common with the petroleum vapors and some other proposed secondary fluids, it has an advantage over steam in this respect. The oily fluids and



PROPERTIES of SULPHUR DIOXIDE VAPOR
TOTAL HEAT - λ -
LATENT HEAT of EVAPORATION - r -
INTERNAL LATENT HEAT - ρ -
PRESSURE - p -
SPECIFIC VOLUME - v -
HEAT of the LIQUID - q
EXTERNAL LATENT HEAT Apu
ALAN E. FLOWERS
ALBERT WALTON
B. T. U. PER POUND.
VOLUME IN CUBIC FEET
PRESSURE IN POUNDS PER SQUARE INCH.
TEMPERATURE IN DEGREES FAHRENHEIT.

the gases do not readily transfer heat by conduction; while steam, on the contrary, possesses a remarkable power of discharge of its heat into a cooler metal and of regaining it when the temperature relations are reversed.

A study of the ideal cycle for this case will give interesting facts and will permit later comparison of the behavior of the real engine with its ideal. In this comparison, the main differences may be expected to prove to be due to the differences in readiness of heat-exchange, the ideal case being entirely free from this sort of waste.

A preliminary study of the tabulated physical properties of the substance should preface this investigation. It will be found that the published tables are usually incomplete and sometimes contain errors which must be carefully checked out. The tables are usually very narrow in range and very limited in number of points of observation. The original authority is Regnault, and it is necessary to go back to his paper in the "Memoirs of the French Academy," Vol. XXVI, for the original experimental data. Later writers have proposed various formulas connecting pressures and temperatures, and, among these, perhaps the best is that of Ledoux.* The work of rectification of data and of smoothing up the tables was undertaken, at the suggestion of the writer, by Messrs. A. E. Flowers and Albert Walton. The tables obtained, reduced to both metric and British measures, are herewith presented. The results of computation of the limited number of points determined were laid down, and the smooth curve thus obtained permitted the detection of errors of computation and a complete rectification of the tables. The originals of the curves for both British and metric measures are preserved in the collections of Sibley College.†

All the values are based on Regnault's experiments; but the formulas used were those proposed by later writers. The quantities were computed at temperatures between 0° C. and 80° C. (32° F. and 176° F.). The values for the

* "Annales des Mines," 1878.

† *Sibley Journal of Mechanical Engineering*, June, 1902.

higher temperatures are presumably not absolutely correct, as they were computed by means of formulas based on experiments at lower temperature ranges; but they are the best that could be obtained.

FORMULAS AND METHODS OF COMPUTATION.

Pressure.—Ledoux gives, in the "Annales des Mines," 1878, the following formula for the boiling pressure at different temperatures:

$$p = a\,\alpha^{\frac{t}{1 + mt}}$$

in which

p = Pressure in kilograms per square meter.
t = Temperature in degrees centigrade.
a = 15,840, a constant; $\log a = 4·199755$.
α = 1·04154, a constant; $\log \alpha = ·017673$.
m = ·0043129, a constant; $\log \alpha = 8·247318 - 10$.

In the original article by Ledoux the value for α is given as 1·04135. The above value for α was computed from the value given by Regnault for the pressure at 35° C.

The following formulas are from Peabody's tables as adapted from Ledoux:

Heat of the liquid, $q = ·36333\,t + ·00004\,t^2$.

Total heat, $\lambda = 91·396 + 0·12723\,t - ·000131\,t^2$.

Latent heat of evaporation, $L = 91·396 - ·2361\,t - ·000135\,t^2$.

External latent heat, $Apu = 8·243 + ·196\,t - ·000116\,t^2$.

Internal latent heat, $\rho = L - Apu$.

Specific volume,

$$v = \frac{BT - Cp^n}{p};$$

where

$$B = 13·882$$
$$C = 3·8455$$
$$n = 0·4487$$

By means of these formulas the quantities were computed for the desired range. These were then converted from the metric to the British system of units, and, for ease in interpolation, plotted on a large sheet of co-ordinate paper, using for common abscissas degrees of temperature.

SYMBOLS EMPLOYED IN TABLE I (METRIC UNITS).

t = Temperature in degrees centigrade.

p = Pressure in kilograms per square meter at which evaporation takes place.

q = Heat of liquid in calories per kilogram.

λ = Total heat of evaporation above 0° C. in calories per kilogram.

L = Latent heat of evaporation in calories per kilogram.

ρ = Internal latent heat in calories per kilogram.

Apu = External latent heat of evaporation in calories per kilogram.

S = Specific volume of the saturated vapor in cubic meters per kilogram.

SYMBOLS EMPLOYED IN TABLE II (BRITISH UNITS).

t = Temperature in degrees Fahrenheit.

p = Pressure of dry and saturated vapor boiling at the given temperature.

q = Heat of the liquid in B.T.U. per pound.

λ = Total heat of evaporation in B.T.U. per pound.

L = Latent heat of evaporation in B.T.U. per pound.

ρ = Internal latent heat of evaporation in B.T.U. per pound.

S = Specific volume of vapor in cubic feet per pound.

SATURATED VAPOR OF SULPHUR-DIOXIDE.

TABLE I. METRIC UNITS.

t	p	q	λ	L	ρ	Apu	S
0	15840	0	91·396	91·396	83·153	8·243	·22583
5	19331·2	1·817	92·027	90·212	81·870	8·342	·18337
10	23397·9	3·673	92·655	89·022	80·595	8·427	·15345
15	28102·6	5·46	93·27	87·82	79·31	8·51	·1292
20	33508·5	7·28	93·89	86·62	78·03	8·59	·1096
25	39681·2	9·11	94·49	85·41	76·75	8·66	·09348
30	46688·8	10·93	95·09	84·19	75·46	8·73	·08025
35	54601·0	12·77	95·69	82·97	74·19	8·78	·06929
40	63485·4	14·60	96·27	81·73	72·89	8·84	·06015
45	73416·3	16·43	96·85	80·49	71·60	8·89	·05248
50	84462·7	18·27	97·43	79·25	70·32	8·93	·046007
55	96698·9	20·10	98·00	78·00	69·03	8·97	·04052
60	110194·0	21·94	98·56	76·74	67·74	9·00	·03584
65	125024·0	23·79	98·81	75·48	66·45	9·03	·031835
70	141222·0	25·63	99·66	74·21	65·16	9·05	·028387
75	158961·0	27·47	100·20	72·93	63·87	9·06	·025407
80	178210·0	29·32	100·74	71·64	62·57	9·07	022820

TABLE II. BRITISH UNITS.

t	p	q	λ	L	ρ	Apu	S
32	22·53	0	164·51	164·51	149·67	14·84	3·6173
41	27·49	3·27	165·65	162·38	147·36	15·02	2·9380
50	33·28	6·55	166·78	160·24	145·07	15·17	2·457
59	39·97	9·83	167·88	158·08	142·75	15·32	2·061
68	47·66	13·10	169·00	155·91	140·45	15·46	1·756
77	56·44	16·39	170·08	153·74	138·15	15·59	1·498
86	66·41	19·67	171·16	151·54	135·83	15·71	1·286
95	77·66	22·98	172·24	149·35	133·54	15·80	1·120
104	90·30	26·28	173·29	147·11	131·20	15·91	·964
113	104·42	29·57	174·33	144·88	128·88	16·00	·841
122	120·13	32·89	175·37	142·65	126·58	16·07	·737
131	137·53	36·18	176·40	140·40	124·25	16·15	·649
140	156·73	39·49	177·40	138·13	121·93	16·20	·574
149	177·82	42·82	178·40	135·86	119·61	16·25	·510
158	200·86	46·13	179·39	133·58	117·29	16·29	·4547
167	226·09	49·45	180·36	131·27	114·97	16·31	·4070
176	253·47	52·78	181·33	128·95	112·62	16·33	·3656

Employing these data, as required, in the comparison of the work of the Berlin secondary engine, from the published accounts of the engine-trials of the machines of which it constitutes an element, we may secure some interesting results. The process adopted by the computers is that usually followed by the writer, adopting the general method of Rankine, with the supplementing and modernization of that system by the introduction, in the real case, of those wastes which do not appear in the purely thermodynamic case. In the present example the question of most interest is that of quantity of extra-thermodynamic waste where the volatile secondary fluid is employed. The data for the real case have been published and are accessible and undoubtedly are entirely accurate.*

The heat reaching the secondary element is that which enters the primary, less the loss, *en route*, by conduction and radiation. The cylinder-condensation waste, it is to be remembered, is not lost as a supply to the succeeding cylinder in any case. All that is absorbed by the metal at entrance

* Berlin Royal Technical High School; Report No. 11, 1899. In English, German and French. Also "Series Vapor and Heat-Waste Engines" R. H. T., *Jour. Frank. Inst.*, October–December, 1902.

of the steam is rejected with the exhaust. It is only the external waste by conduction and radiation and the transformed energy which leaves the system absolutely. Even the friction of the piston in the cylinder reproduces heat, by reconversion of mechanical work into heat, for use by the succeeding element. The heat reaching the larger cylinders of the primary and of the secondary is thus very nearly the full amount entering the high-pressure cylinder of the primary element of the binary engine, less only the equivalent of work performed.

In the tabulated results of Professor Josse's experiments are given the temperatures and pressures of entering and exhaust steam and of entering and exhaust sulphur-dioxide. The limits for the ideal cycles computed were taken as the sulphur-dioxide pressures given for the tests recorded as Nos. 4, 7, 8 and 12.* The initial pressure, p_1, is taken as the absolute pressure at the vaporizer, while the final pressure, p_2, is the absolute pressure of the condenser. In this, the atmospheric pressure is assumed to be the average value of 14·5 pounds per square inch. From these pressures the corresponding values required for computation were found on the curves, as tabulated on the accompanying data sheet.

The heat actually supplied to the SO_2 engine was taken as the total available heat of the superheated entering steam, less the heat-equivalent of the indicated work in the steam-engine, and with a certain allowance for external radiation and conduction losses. The allowance for these losses was about 3 per cent. of the total amount of heat entering the steam-engine. The loss was assumed to be slightly greater for the one case where the steam was nearly saturated, 80,000 B.T.U. per hour being allowed, and 70,000 B.T.U. per hour in the other cases.

The amount of the thermal waste was taken as the difference between the heat-input so calculated and the heat required for an *ideal* SO_2 engine of equal power working through the same range. The amount of this waste, divided by the range of temperature worked through, and by the

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* *Jour. Frank. Inst.*, December, 1902.

area of the internal surface of the SO_2 cylinder, gave the heat-waste in B.T.U. per square foot per degree difference of temperature per hour. This quantity was divided by 60 to reduce it to the heat-waste per minute. The figure thus found for the heat-waste is about that observed for simple condensing steam-engines.

DETERMINATION OF AMOUNT OF HEAT ENTERING SO_2 ENGINE.*

	I.	II	III.	IV.
Temperature of boiler steam	189·5	302·0	330·0	301·0
Temperature Fahrenheit	373·1	575·6	626·0	573·8
Pressure, lbs per sq. in. gage	156·5	156·5	156·5	158·0
Pressure, lbs., absolute	171·0	171·0	171·0	172·5
Corresponding temperature	368·6	368·6	368·6	369·3
Total heat above 32° of dry saturated steam B.T.U. per lb.	1194·4	1194·4	1194·4	1194·6
Superheat, degrees	4·5	207	257·4	204·5
B.T.U. per lb. due to superheat, 0·4805 x D	2·16	99·5	123·7	98·3
Total heat of steam above 32° in B.T.U. per lb.	1196·6	1293·9	1318·1	1292·9
Per cent. of vacuum	68·2	79·5	75·2	68·5
Absolute pressure of vacuum	4·61	2·975	3·598	4·57
Heat of liquid of exhaust	127·0	109·6	116·6	126·6
Available heat in steam in B.T.U. per pound	1069·7	1184·6	1201·5	1166·3
Total weight of steam per hour	2562	1980	1197	2142
Available heat in steam in B.T.U. per hour	2740571	2345508	1438195	2383197
Horse-power of steam-engine	156·3	145·3	82·4	163·2
B.T.U. equivalent of I.H.P.	397783	369788	209708	415344
Assumed loss by radiation and conduction	80000	70000	70000	70000
B.T.U. per hour available for SO_2 engine	2262788	1905720	1158487	2012871
Horse-power of SO_2 engine	66	50·1	30·6	54·7
Heat required for ideal engine of same range and H.P.	1375440	1189073	635195	1048052
Heat-waste in B.T.U. per hour	887348	716647	523292	964819
Temperature range	82·35	69·40	81·70	90·83
Internal area of SO_2 cylinder in sq. ft.	5·692			
Heat-waste in B.T.U. per degree per square foot per hour	1893	1814	1125	1644
Heat-waste in B.T.U. per degree per square foot per minute	31·55	30·23	18·75	27·39

* See Manual of the Steam-Engine, Thurston. Vol. I, p. 995, *et seq.*

SYMBOLS, TABLE III.*

p_1 = Absolute initial pressure = gage pressure in vaporizer + 14·5 pounds per square inch, atmospheric pressure.

T_1 = Absolute temperature in Fahrenheit degrees = 461° + temperature of ebullition, from curve.

v_1 = Initial volume of SO_2 vapor, from curve.

p_2 = Absolute final pressure in SO_2 condenser, 14·5 pounds per square inch, the assumed pressure of the atmosphere.

T_2 = Absolute final temperature in Fahrenheit degrees, temperature of ebullition corresponding to p_2, from curve.

v_2 = The final volume of SO_2 vapor, from curve.

r = Ratio of expansion = $V_2 + V_1$.

λ = Total heat of entering SO_2 vapor, from curve.

q_2 = Heat of the liquid of exhaust, from curve.

L = Latent heat of evaporation, from curve.

H_1 = Energy per pound in foot-pounds of entering SO_2 = $J(\lambda - q_2)$.

H' = Energy per pound in foot-pounds of the latent heat of evaporation = JL.

U = Useful energy per pound of SO_2 vapor in foot-pounds

$$= Jc'\left(T_1 - T_2\left(1 + \log_e \frac{T_1}{T_2}\right)\right) + \frac{T_1 - T_2}{T_1} H'.$$

E = Efficiency

$$= \frac{U}{H}.$$

$M.E.P.'$ = Mean effective pressure in pounds per square foot

$$= \frac{U}{v_2}.$$

$M.E.P.''$ = Mean effective pressure in pounds per square inch

$$= \frac{M.E.P.'}{144}.$$

* *Ibidem.*

A = B.T.U. per I.H.P. hour

$$= \frac{2545}{E}.$$

B = Pounds of SO_2 per I.H.P. hour for efficiency unity

$$= \frac{1980000}{H_1}$$

C = Pounds of SO_2 per I.H.P. hour for actual efficiency

$$= \frac{B}{E}.$$

D = Piston displacement per I.H.P. hour = Cv_2.

D' = Piston displacement per I.H.P.

$$= \frac{D}{60}.$$

F = Pounds of exhaust steam per I.H.P. hour = A divided by the latent heat of the exhaust steam.

J = Mechanical equivalent of heat = 778 foot-pounds.

c' = Specific heat of SO_2 liquid found from curve between temperature limits of 50° and 158° F. = 0·3665.

The formula for U, as given, is based on the assumption that the expansion is complete, and that the final pressure is equal to the back pressure.

SULPHUR-DIOXIDE CYCLES.

	I.	II	III.	IV.
T_1	616·5	600·95	610·6	621·0
p_1	194·5	156·7	179·4	206·5
v_1	0·468	0·574	0·506	0·443
T_2	534·15	531·55	528·9	530·17
p_2	52·5	50·0	47·6	48·7
v_2	1·602	1·678	1·760	1·720
r	3·425	3·923	3·478	3·882
λ_1	179·05	177·35	178·40	179·50
q_2	15·0	14·05	13·10	13·6
L	134·2	138·25	135·7	133·1
H_1	127630	127047	128603	129070
H'	104400	107558	105574	103552
U	15587	13623	15765	17144
E	·12212	·10723	·12260	·13283

M.E.P.'	9729·7	8118·7	8957·4	9967·4
M.E.P.''	67·56	56·37	62·20	69·21
A	20840	23734	20758	19160
B	15·514	15·58	15·40	15·34
C	127·04	145·29	125·60	115·49
D	205·82	243·80	221·06	198·64
D'	3·43	4·063	3·68	3·31
F	20·182	23·367	20·554	19·061

The expenditure of heat in the secondary cycle, *A*, thus averages, for the ideal case, about 20,000 B.T.U. per I.H.P. hour, not a remarkably low figure; but on the other hand, it costs nothing, as it is supplied by the waste of the primary element of the combination. The quantity of SO_2 per I.H.P. hour for unity efficiency, *B*, under the conditions of its employment in this case, is a trifle above 600 pounds; but this amount is unimportant, commercially, as this is a circulatory system, and once the charge is received into the system, it costs nothing except for renewal or leakage. The quantity demanded for the actual efficiency, *C*, is about 130 pounds and the same remark here applies. The piston displacement per I.H.P. hour, *D*, is about 220 cubic feet, and this will vary with the mean effective pressure on the piston. The same figure, reduced to expenditure per minute, becomes about 3·66. The weight of steam entering the secondary element, per I.H.P. hour, *F*, averages a little more than 20 pounds.

Comparing these figures with those of the trials, as observed and reported as the actual consumption of heat and steam in the secondary engine, it is found that about one-half of the supply to that element is wasted by extra-thermodynamic methods of rejection. How much of this is leakage and how much is thermal waste cannot be determined from the data. It does not appear, however, from this examination of the case that the wastes are less than in the steam-engine in similar cycles. It is, however, sufficiently evident that the main source of the gain observed, when the secondary element with its volatile working fluid is introduced, is to be found in the fact that the result is the securing of high absolute pressures and of large mean effective pressures, with relatively small variation of volumes, at a

part of the thermal range at which steam does not give us pressures of sufficient magnitude to permit the maintenance of satisfactory mechanical efficiency of the engine or to produce commercially satisfactory sizes and weights of the motor.*

MINUTE MECHANISM.

Modern Machinery contains some interesting facts about the minuteness of some of the screws made in an American watch factory. It takes nearly 130,000 of a certain kind to weigh a pound. Under a microscope, they appear in their true character—perfectly finished bolts. The pivot of the balance wheel is only $\frac{1}{200}$ of an inch in diameter, and the gage with which pivots are classified measures to the $\frac{1}{10000}$ part of an inch. Each jewel hole in which a pivot fits is about $\frac{1}{5000}$ of an inch larger than the pivot to permit sufficient play. The finest screw for a small-sized watch has a thread of 260 to the inch, and weighs $\frac{1}{130000}$ of a pound. Jewel slabs of sapphire, ruby or garnet are first sawed into slabs $\frac{1}{30}$ of an inch thick and are shellacked to plates so that they may be surfaced. Then the individual jewels are sawed or broken off, drilled through the center, and a depression made in the convex side for an oil cup. A pallet jewel weighs $\frac{1}{150000}$ of a pound; a roller jewel a little more than $\frac{1}{236000}$. The largest round hairspring stud is $\frac{1}{100}$ of an inch in diameter and about $\frac{9}{100}$ of an inch in length.

ALUMINUM ALLOYS.

Aluminum World is authority for the statement that an alloy consisting of 18·87 per cent. of aluminum and 81·13 per cent. of antimony is a marked exception to the general rule that alloys are more fusible than the least fusible metal contained. Aluminum and antimony melt at nearly the same point, which is in the neighborhood of 1,160° F.; this alloy does not melt until a temperature of 1,976° F. is reached. Most alloys are denser than their constitutents; this alloy is less dense. Quantitatively, 7·07 cubic inches of aluminum, alloyed with 12·07 of antimony, produces 23·71 cubic inches of alloy, thus showing an increase in volume of 4·55 cubic inches, or 24 per cent.

The *Iron Age* gives us the following item:

A French engineer is alleged to have discovered alloys for aluminum which impart to this metal most extraordinary qualities. By varying the amount of his alloy from 1 part in 12 to 1 part in 240 he obtains compounds varying in tensile strength from 29,000 to 58,000 pounds per square inch. These are so different in characteristics that they may be chased, soldered, brazed, forged, rolled into plates and leaves, or drawn into wire, all depending on the amount of the alloy. It can be made soft, like pure aluminum, or stiff and rigid like steel, and possessed of nearly the same strength, on one-third the weight.

* For details of methods of treatment and of computation, see Manual of the Steam-Engine, Vol. I, §§ 137, 149, 155, and notes, pp. 995-1004. R. H. T.

ELECTRICAL SECTION.

Stated Meeting, held Thursday, February 12, 1903.

Notes on Recent Electrical and Scientific Developments Abroad.

BY WILLIAM J. HAMMER,
Consulting Electrical Engineer, New York.

(*Concluded from p. 340.*)

RADIUM, POLONIUM AND ACTINIUM.

I have brought with me to-night a collection of tubes containing phosphorescent substances which I have been gathering abroad and in this country. These substances which I will show you become phosphorescent when exposed to some source of vibration, such as light, heat and electricity. Practically, all substances in nature are phosphorescent to a greater or less extent.

Certain of these phosphoresce for only one-ten-thousandth of a second, while others for many hours.

A substance, such as sulphide of calcium, which I have here in this bottle, may be exposed to sunlight, and after being put away for six weeks in the dark will still affect a photograph plate.

By burning this piece of magnesium wire before these tubes, you will notice that they become brilliantly phosphorescent, and show a large variety of shades of colors.

I now wish to call your attention to those most remarkable substances which are probably attracting more attention in the scientific world than any substances which have ever been discovered. These are radium, polonium and actinium.

I have brought with me to-night some nine different preparations of radium, the most powerful of which has a radioactivity of 7,000, and also two tubes containing a preparation of polonium and bismuth in the metallic and subnitrate forms.

In the discovery of these remarkable properties we must

go back first to the experiments of M. Henry and M. Niewenglowsky. The former showed that phosphorescent sulphide of zinc penetrated black paper and affected a photograph plate similar to Roentgen rays; and the latter placed a photograph plate in a plate-holder, covering the same with a sheet of aluminum, on which he placed a number of square pieces of glass. On this glass he sprinkled sulphide of calcium, which had been exposed to sunlight; and after covering over each of the glasses with a watchmaker's glass, resembling a goblet with the stem cut off, he put the plate away for a period of twenty-three hours; after which, on developing the same, he found that the squares of glass and the rim of the goblets were plainly photographed on the plate.

The rays which penetrated the aluminum were ordinary light-waves, which were shown by the refraction of the light where it had passed through the rim of the glass covers.

Becquerel, at about this period (1896) was experimenting with various phosphorescent substances, and exposed some salts of uranium (double sulphate of uranium and potassium) to sunlight to make them phosphoresce, and was then trying their effect on a photograph plate. During a period of inclement weather he put the plate away in a drawer, and after several days he took the plate out and developed it, when, much to his surprise, he secured a better image than he had made before by exposure to sunlight. This led to his discovering and investigating the properties of what have ever since been called "Becquerel" rays.

This was in 1896, and subsequently in 1898, Prof. P. Curie and his wife, Mme. Sklodowska Curie, in studying these Becquerel radiations, found some samples of pitchblende, from which the uranium is extracted, which was much more powerful than any uranium they had ever found; and this convinced them that there must be some substance in uranium which produced Becquerel rays. After much painstaking investigation they succeeded in discovering a new element which Mme. Curie named Polonium, after Poland, her native country.

Polonium, in its chemical and other characteristics, bears a marked resemblance to barium, with which it is associated.

During the same year M. and Mme. Curie and M. Bemont succeeded in isolating a new substance which they called "radium," which possesses the same chemical and other characteristics of barium with which it is associated.

In 1899, M. Debierne discovered a new preparation which possessed the chemical and other characteristics of thorium, which he named "actinium."

These three substances, all of them being produced from the uranium residues, are spoken of as new elements, although in the case of polonium and actinium they have as yet not been prepared of sufficient quality and quantity to absolutely demonstrate that they are new elements. In the case of radium, however, this has been demonstrated beyond peradventure.

During my visit in Paris last September I had the pleasure of visiting Professor Curie at his laboratory and seeing some very interesting experiments; and among other things he showed me a tiny tube containing between $\frac{2}{100}$ and $\frac{3}{100}$ of a gram of radium. This he held up to the light and stated that it represented the only samples of chemically pure radium in the world. I asked how he had demonstrated it to be chemically pure, and he said that this was the sample with which M. Demarcay had made his investigations with the spectroscope, and had shown that there were only present the lines characteristic of radium, and this was the identical sample with which the atomic weight had been determined to be 225, while that of barium, with which it is associated, is but 157.

I asked Professor Curie what was the value of this tiny tube, which is about the size of a buck-shot, and he said that the value was anything which one might place upon it; and on my asking whether $20,000 would buy it he said, no, indeed; but he showed me a tiny tube which contained perhaps $\frac{3}{100}$ of a gram which still contained a considerable trace of barium, which he was willing to dispose of for the sum of $5,000.

Up to the present time the laboratory at which the radium is prepared, and which is under the control of Professor Curie, has not permitted any radium to be sent out with a radioactivity over 7,000, the better grades being retained for investigations going on at the laboratory.

I have within a few days, however, received a letter from the laboratory stating that very shortly radium would be placed upon the market at a cost of 30,000 francs or $6,000 per gram ($2,721,555.90 per pound).

Radium is by far the most interesting of the three new substances which have been discovered, and its remarkable properties have very much unsettled the minds of the scientific world; and none of the theories which have up to the present been advanced satisfactorily account for all the phenomena due to radium.

My friend, Mr. R. R. Bowker, whom I met in Paris last fall, told me that he had shortly before that been dining with Lord Kelvin seated on one side and Professor Becquerel on the other, and Lord Kelvin had turned to him and stated that the discovery of Becquerel radiations had placed the first question-mark against the principle of conservation of energy which had ever been placed against it since that principle was enunciated.

I will now endeavor to tell you of a few of the remarkable properties which these new elements possess. First, however, I will pass around the room, and if the lights are put out, show you some half dozen or more tubes of radium, which you will note are brilliantly phosphorescent in the dark.

Now, in contradistinction to the substances which I showed you, and which I excited by burning the magnesium wire, these tubes of radium give off this powerful light without having to be excited by any vibrations of any character, so far as we know.

Preparations of radium have been made in a dark room and have been kept there for a period of two years, and during that time have not lost their luminosity in the slightest degree.

One might almost consider that this substance is matter

tearing itself into pieces and projecting these pieces with from half to the full speed of light, for the particles are evidently carried through all matter. The very walls of this room and the clothes of those who are present are at this moment all radioactive, due to the presence of radium in the room. This and other phenomena of radium cause one to naturally "hark back" to the Newtonian corpuscular theory of light.

Professor Curie told me that he was frequently forced to delay his tests for a period of three or four hours by reason of the fact that he had been exposed to some radium, and his clothes had become so radioactive as to prevent his going near his instruments.

By wrapping a little cotton around one of these tubes and holding it in the dark you will find that the entire mass is brilliantly phosphorescent. This is not due to the mere light passing through the cotton, but to the fact that the cotton itself has become radioactive.

Elster and Geitel have shown that if a wire is placed in the atmosphere and charged negatively from a source of current, say 500 volts, the wire itself becomes radioactive, and this radioactivity can be scraped off, and will affect photograph plates, ionize the air, etc.

McLennan has made experiments on this line in Montreal, and subsequently negatively charged a wire placed at the foot of Niagara Falls from the electricity present in the atmosphere, and produced a result about $\frac{1}{6}$ as powerful as that produced in Montreal.

It is well known that falling rain and snow are for a time quite powerfully radioactive, and after a snowstorm the wire negatively electrified in the atmosphere has only a small amount of radioactivity, showing that the snow has probably carried the radioactive particles in the atmosphere down with it to the ground.

Professor Rutherford, of Montreal, one of the ablest investigators of radioactivity, has given a great deal of attention to thorium, which is the most radioactive substance next to radium which has been discovered. He electrified a wire negatively by connecting one side of a battery of 500

volts to the wire, and grounding the other side of the battery; and by connecting the sample of thorium to the ground he attracted the thorium particles to the negatively charged wire and produced a greater radioactivity than he has ever found in any thorium preparation which he has made.

Radium has three entirely distinct classes of rays.

The "α"-rays, which constitute by far the most important class of these and the largest quantity, are those which produce the greater portion of the ionization of the air observed under experimental conditions.

These rays have in common certain of the characteristics of X-rays, and by many have been thought to be X-rays.

Rutherford has, however, recently shown that these rays in a powerful field are slightly deflectable. Originally they had been considered absolutely non-deviable, as are X-rays.

These "α"-rays are readily absorbed, and a thin screen of any metal will serve to cut off the greater portion of them.

The "β"-rays are much longer and much more penetrative, and in every respect possess the qualities of cathode rays. They are readily deflected by a magnet, discharge electrified bodies by ionization of the air, and affect photograph plates, etc.

Crookes and Strutt suggested that the "α"-rays consist of positively electrified bodies, and Rutherford supports this, stating that they have characteristics similar to Goldstein's Canal Strahlen, which have been shown by Wien to be positively charged bodies moving at high velocity; although Rutherford considers that the particles from the "α"-rays move at much higher velocity than the Goldstein rays. Rutherford estimates that the energy of "α"-rays is a thousand times greater than that of "β"-rays; and some experiments made by him show that the relative penetration of the three classes of rays in passing through a certain thickness of aluminum before half of the intensity is reduced is as follows:

	Thickness of Aluminum
"α"	·0005 cm.
"β"	·05 cm.
"γ"	8· cm.

The X-rays are the rays with the greatest penetrative quality, and may produce an effect in the air even a meter or more distant. These rays are not at all influenced by a magnet.

The Curies have shown that radium dissolved in water and evaporated to dryness very largely loses its power of emitting "β"-rays, and it appears that the emission of "α"-rays goes on entirely independent of the "β"-rays; and it is now considered that the "β"-rays are a secondary phenomena, the "α"-rays playing by far the principal part in changes which occur.

The rays from radium produce many interesting chemical effects.

I hold in my hand here a large glass bottle, which I secured at the Paris laboratory, which contained radium, which has been powerfully affected by radium rays changing it to a deep violet color, which will always remain.

I also hold in my hand a tiny tube in which the chemical constituents of the glass have been such that when the radium acted upon them the glass was changed to a dark brown. This tiny tube is a duplicate of the very interesting tube which Professor Curie showed me, which contained between two and three grams of chemically pure radium.

Glass, porcelain, paper and other substances are changed in color by the action of radium.

Platino barium cyanide is changed from a greenish-yellow to a brown variety when it polarizes light, like the tourmaline crystal.

White phosphorus is changed to red phosphorus in about twenty-four hours.

None of the rays from radium can be refracted, reflected or polarized, showing that they are not light waves.

Prof. J. J. Thomson, in his address before the British Association last summer, repeating statements of Professor Becquerel, stated that if a square centimeter of surface were covered with pure radium it would only lose in weight ·001 milligram of the substance in a million years.

Recently, however, Heydweiller, of Germany, has stated that a preparation of de Haen's radium, which he had

tested, lost ·02 milligram per day, and that in fifty days an entire milligram in weight had been lost.

I wrote to Professor Thomson asking him to account for the discrepancy in the two statements, and he wrote me that while he was not entirely familiar with Heydweiller's experiments, and was not quite certain of the cause of the loss claimed, he called attention to the effect which radium produces of coloring glass in which it is placed a deep violet color, and he stated that if this coloring went entirely through the glass, as he was led to suppose, there was perhaps a reaction when the rays appeared on the outside of the glass which caused destruction of the glass itself and lessening in the weight of the glass envelope, and not of the radium itself.

The original statement made by Professor Thomson was based on the statement of Professor Becquerel; and Becquerel's statement was based upon the investigations which he had made on the deflectable or β-rays.

With the tremendous velocity with which the particles are projected through all matter, one would be led to suppose that there must be some loss in weight where all the phenomena of the radiation are taken into consideration; but there are those who believe there is an equilibrium process going on with radium, so that the actual loss is infinitesimal.

J. J. Thomson and Rutherford advance the theory that there is a succession of chemical changes going on, causing the spontaneous projection of larger masses of material at enormous velocities, and that while certain portions are constantly dying out and becoming inert, other portions are constantly increasing in strength and power.

Mme. Curie had advanced the theory that there may be present in the ether certain vibrations with which we have not been cognizant, with which radium vibrates in harmony the moment it is created.

Radium produces most powerful physiological effects.

Professor Curie showed me a scar on his arm which had been caused by a serious ulcer produced by some radium which he had placed in a small capsule, and put it on the

outside of his coat sleeve for a period of about an hour and a half. The back of his hand was also badly burned and the skin all peeled off, due to the small sample of radium of very high radioactivity which he had placed on the back of his hand for a period of about five minutes.

Those who have worked with radium have noted that the finger-tips become exceedingly sensitive in handling radium, and the writer recently experienced considerable soreness for over a month, due to carrying a wooden box with a number of tubes of radium under his arm for several hours, while attending the American Association meeting at Washington during the Christmas holidays. The radium was in sealed glass tubes, and the tubes placed in glass bottles laid in cotton inside of the wooden box. The manifestations of burning from radium, which are very similar to X-ray burns, do not display themselves for a period of about two weeks after exposure. Quite a number of instances are recorded of the serious character of the radium burns, and in talking with Professor Curie I asked him whether he had ever seen a kilo of radium, and whether a kilo of radium had ever been produced, and he said no; that in the last three years, with all the work that had been done in Germany and France, only between 500 and 600 grammes of radium had been produced, *i. e.*, in the neighborhood of a pound. He stated, furthermore, that he would not care to trust himself in a room with a kilo of radium; and on my asking him why, he said because it would destroy his eyesight, burn all of the skin off his body, and probably kill him.

There are great possibilities in the use of radium for the treatment of certain classes of disease. Aschkinass and Caspari have exposed some cultures of micrococcus prodigiosus to radium, and in three hours they have all been killed.

Some promising results have also been claimed by Dr. Oudin from its use in the treatment of lupus. There are also possibilities in the treatment of neuralgia and the diagnosing of paralysis of the optic nerve. If a tube containing radium is held to the closed eye or against the temples, a powerful impression of light is produced. This is

due probably to the action of the radium on the phosphorescence in the pupil of the eye, and possibly also to its action on the nerve centers.

If a pile of seeds is divided into two parts and one portion is exposed to radium for a considerable period, and then both piles are planted, it is found that the seeds exposed to radium have lost their germinating properties.

Professor Curie informed me that radium emits exactly the same quantity of Becquerel rays when exposed to liquid air as it does at the normal temperature of the atmosphere; that the luminosity of the chloride of radium is stronger in the liquid air than in the atmosphere at normal temperature; but that the strength of the radiation is not altered.

If a gold-leaf electroscope is charged negatively by a rubbed ebonite rod, and the leaves caused to diverge, one can, by bringing some radium near the electroscope, cause the leaves to come together, showing that the air has been ionized, or made a conductor of electricity, and thus dissipating the charge in the gold-leaf.

If some radium is put in a lead vessel, beneath two plates of a condenser, one side of the condenser being attached to a source of current, say 500 volts, and the other side of the battery being grounded; and if the other plate of the condenser be connected to an electrometer, the radium rays will pass up between the plates of the condenser, making the air a conductor of electricity, so that the current will pass across from one plate to the other and measurements may be made by means of the electrometer.

In addition to the chemical effects already referred to, radium rays will reduce silver salts, bichromate of potash and peroxide of iron in the presence of organic substances. They will also reduce chlorine in the presence of oxalic acid with a precipitation of calomel. Oxygen is also changed into ozone.

The little bottle of sulphide of calcium which I showed you and which I exposed to the light, was not phosphorescent all the way through the mass, but in the case of radium the light is given from the entire mass.

All substances in the neighborhood of radium become radioactive, and this radioactivity which is imparted may produce for a time the same effects as the original substance.

Professor Curie states that one-half of this induced radioactivity, when exposed to the air, is lost in certain substances in half an hour; but in a closed vessel, where the air has been made radioactive, this radioactivity has not lost half of its strength in four days.

Radium is somewhat hygroscopic, and it should therefore be kept free from moisture in sealed tubes. If exposed to moisture it soon loses its luminosity; but this may be recovered by making a solution and precipitating the substance and thoroughly drying it. The luminosity may be very largely increased by subjecting the radium to very high temperatures.

Actinium, which was discovered by M. Debierne, and is similar to thorium, is precipitated by ammonium sulphhydrate. The rays from actinium are deviable.

Polonium, which was the original element discovered and which resembles bismuth, is precipitated by hydrogen sulphide.

I hold in my hand here two small tubes of polonium, in the subnitrate and metallic forms. The latter resembles metallic particles of nickel.

Professor Crookes has shown that the rays from polonium do not penetrate glass; they only extend about 4 centimeters from the original source and are nondeflectable.

Giesel, however, has prepared a form of polonium which possesses both deviable and nondeviable rays.

The Curies have not been able to prepare any which is deviable.

Elster states that when polonium is placed in a vacuum the rays emanating from it deviate to a greater extent than those of radium.

Polonium apparently loses its power much more rapidly than radium.

In the preparation of radium it is necessary to refine some 5,000 tons of uranium residues to produce a little over

2 pounds of radium, and it costs about $2,000 per ton to refine these residues.

More attention in the scientific world has been attracted to the phenomena of these radioactive substances than was attracted by the discovery of Roentgen-rays, or X-rays; and it is doubtful if anything has been discovered since the beginning of the world which has possessed such fascinating interest to scientific men, and which is so fraught with possibilities; and it seems likely to contribute to our knowledge of the constitution of matter to a degree which no other substance heretofore discovered has ever done.

I shall now show you a number of interesting lantern slides of photographs made with phosphorescent substances and radium, which show certain of the X-ray and other characteristics of the radium rays, and also an illustration of the apparatus used by Professor Curie in testing the radioactive properties of radium. In this connection it is interesting to note that electrical analysis with the electroscope and electrometer has proven a million times more sensitive than chemical analysis, and thousands of times more sensitive than spectrum analysis; and that the electroscope will test the radioactivity of a preparation of radium, which it is necessary to produce 5,000 times as powerful in order to have it show in the spectroscope.

FINSEN'S ULTRA-VIOLET RAY TREATMENT OF DISEASE.

During my sojourn in Europe last year business called me to Copenhagen, and while there I had the pleasure of visiting the Finsen Medical Light Institute, established in 1896, and was very much impressed with the beneficent results derived from Finsen's treatment of disease by the ultra-violet light.

I hold in my hand a copy of Gen. A. J. Pleasonton's book, entitled "Blue and Sunlights: Their Influence upon Life and Disease," which I picked up some years ago in a second-hand book-store for the munificent sum of 15 cents, and to those who are interested in the bactericidal effects of light upon disease germs I would commend to them the consideration of this book, which carries one back to the

blue-glass craze of 1876 and thereabouts. Although he was branded a charlatan, and his system made the butt of the funny papers, Finsen says: "The General was absolutely on the right track."

Professor Finsen has conducted some very elaborate and painstaking researches into the treatment of disease by ultra-violet light, and has found both ends of the spectrum to possess remarkable curative powers; and he has employed most successfully the red end of the spectrum in connection with the treatment of small-pox; and has also found it most successful in the removal without pain of such disfigurements as birth-marks, moles, etc. And then, by using the other end of the spectrum containing the blue-violet, and especially the ultra-violet rays, he has very successfully combated that horrible disease, tuberculosis of the skin, or "lupus," a disease which heretofore has baffled surgical skill.

It is interesting to note that in New York City alone there are 20,000 cases of tuberculosis, and 8,000 deaths annually—this disease exceeding, probably, in importance and deadly character, all diseases which flesh is heir to.

When attacking certain of the internal organs it appears as consumption; but on attacking the skin or flesh tissues it produces tuberculosis of the skin and is known as that loathsome disease, "lupus" (wolf). It is said that there are no bacillogenous diseases of the skin of such clinical importance and interest as the varieties of primary and secondary tuberculosis.

The investigations of Koch and others have demonstrated the presence of specific organisms, which have been named tubercle bacillus, present in both the internal and cutaneous forms of the disease.

Lupus appears in a number of forms; but its most important and most common is that of "lupus vulgaris." As a rule, it appears in single patches. The face is the favorite seat of the disease, especially the nose, cheek and mouth. It also frequently attacks the extremities, and may appear anywhere.

When Professor Finsen first began his work little cre-

dence was given to the results which he claimed; but to-day too much cannot be said in his praise, and the results claimed by him have been verified by many others in different parts of the world; and it is interesting to note that recently Professor Finsen has received the award of the Nobel prize of $50,000 for his interesting contribution to medicine and surgery.

In the treatment of small-pox Professor Finsen found that by placing the patients in a room from which ordinary sunlight was excluded, the room being illuminated only by the rays which penetrated through red glass, such as one would use in a photographic dark-room, the red rays had a soothing effect upon the patients and prevented entirely the suppuration, if treated before the suppuration stage, and also the scarring usually resulting; the fever accompanying the eruption disappeared, the temperature remained normal, and the disease was always of a much milder form.

If such patients were subjected to the rays of the blue, violet, and ultra-violet end of the spectrum, the disease would be very much aggravated.

Even parties who have been exposed to red rays in a room have been found to have had the disease very much aggravated by going out in the sunlight before fully cured. This aggravation of the disease is caused by actinic rays, or the most refrangible rays, which produce a sunburning which one often experiences in high altitudes, where the temperature may be considerably below zero, and has often been observed by those who are working close to arc lamps. This excitation or stimulation produced by these rays, while it is very harmful in cases of small-pox, is the very thing that is needed in such diseases as tuberculosis of the skin and lupus vulgaris. Here it is found that the bacilli are killed, nutrition and granulation are stimulated, and the patients are ultimately cured of the disease.

The rays of the sun are undoubtedly very rich in blue, violet and ultra-violet light; but in passing through the atmosphere these rays are very largely absorbed, and they are too slow for the most effective treatment; besides the sun was often obscured; and Professor Finsen in his recent

work has therefore employed a carbon arc light, using from 40 to 80 amperes and 45 to 50 volts, which source of light is much richer in ultra-violet rays; and others, such as Broca and Chatin, in Paris, and Görl, of Erlangen, have used the iron and aluminium arcs, which are still richer in ultra-violet rays, and which, it is claimed, also enables more rapid treatment than in the case of the carbon arc—Broca claiming his iron lamp will do in twenty minutes what Finsen does in his treatment of one hour and ten minutes.

In Professor Finsen's first experiments he employed a glass bottle which was practically a plano-convex lens. This flask was filled with a light-blue ammoniacal solution of sulphate of copper, and subsequently with plain water, and the sun's rays were passed through this solution and focussed upon the patients to be treated.

In the more recent treatment in which the arc-lamp is employed, a telescope containing four rock-crystal lenses is employed, the rays of the arc-lamp being passed through these rock-crystal lenses and also through chambers containing distilled water, these serving to cut off and absorb the heat rays of the spectrum while they allow the ultra-violet rays to penetrate.

A rock crystal 4·4 millimeters thick will allow 60 per cent. of the ultra-violet rays to pass through it, whereas ordinary glass almost entirely cuts these rays off.

Around the portion of the telescope containing the distilled water is a jacket containing circulating water to conduct away the heat.

It is found that blood does not permit ultra-violet rays to pass through it, and it is therefore necessary to drive the blood from the diseased portion of the skin. This is accomplished by a plano-convex lens of rock crystal which is kept cool by circulating water. It is claimed that by the use of the iron arc water cooling is unnecessary, and that pressure to drive blood away is also unnecessary.

When the glass is pressed on the diseased part the pressure drives the blood away from that portion and allows the rays to penetrate. At the Finsen Institute it is usual to expose the patient to a treatment of an hour and ten minutes,

after which the patient appears as if he had been badly sunburned. He is then allowed to recuperate until the next day, and the treatment is continued over and over again. After a certain number of treatments the patient is generally dismissed as cured; but while in some cases there is no recurrence, in other cases it is found that the microbes which were deep-seated have worked their way to the surface, and it is necessary for a second course of treatment, and sometimes three or more; although in many cases two or three sets of treatment are all that is sufficient to absolutely cure the patient of this loathsome disease. Of over 600 cases treated at Copenhagen it is claimed there have been no failures due to fault in treatment, though some had progressed too far before treatment commenced.

The charge for the treatment only ranges from $18 per month to less than $1 per day.

I have here some photographs and slides, which I secured through the courtesy of the Finsen Institute, which show a number of the patients before and after this treatment. One cannot look at these without feeling impressed with the glorious work which has been accomplished by Professor Finsen, and which is now being taken up all over the civilized world, and which is opening up a new life to many of the most sorely afflicted people of this world of ours.

SELENIUM.

Before closing my lecture I wish to invite your attention to that remarkable substance "selenium."

It was discovered by Berzelius in 1817 as a by-product in the manufacture of sulphuric acid from the distillation of iron pyrites. Its characteristics are similar to sulphur, phosphorus and tellurium. If melted at 212 degrees Centigrade and cooled rapidly it becomes a brown amorphous mass of conchoidal fracture, and in this form is a non-conductor of electricity. If heated to only 100 degrees Centigrade for a considerable period, it becomes a conductor of electricity to a slight extent, this increasing with the increase of current.

Hittorf in 1851 first discovered the effect of temperature on selenium.

On February 12, 1873, Mr. Willoughby-Smith presented a communication to the Society of Telegraph Engineers of London, referring to the effect of light in reducing the resistance of selenium. An assistant of his, Mr. May, a telegraph clerk at Valencia, had noted these phenomena in some selenium resistances used in connection with the cable work, and called the attention of Mr. Willoughby-Smith, who had charge of the submarine cable testing, to them.

At the present time there is a considerable revival of interest in the properties of selenium, and notable advances have been made. Much work has been done in this direction in the past by Messrs. Shelford Bidwell, F.R.S., J. W. Giltay, Lord Ross, Sale, Draper and Moss, W. G. Adams and R. E. Day, Mercadier, Fritts, Ruhmer, Minchin, Bell and others.

Prof. Alexander Graham Bell has made some interesting experiments with his radiophone, in which a silvered diaphragm, which reflected a powerful beam of light, fell upon a selenium cell connected to a telephone and battery. At the back of the silvered diaphragm was a flexible tube or mouthpiece, into which words were spoken. This caused the diaphragm to vibrate, sending pulsations of the reflected light upon the selenium cell, which correspondingly varied its resistance and produced audible sounds in the telephone.

Subsequently, Professor Simon, of Germany, discovered that the light of an arc lamp placed in proximity to a telephone circuit was caused to vibrate perceptibly while the telephone was being operated, and he devised a speaking arc by superimposing the sound waves produced by the telephone upon the circuit in which the arc was placed.

Subsequently this work was taken up by Duddell, of England, and Ernest Ruhmer, of Berlin, the latter particularly following this matter most industriously and producing results of far-reaching importance, and surpassing those which had been attained by others.

I had the pleasure of seeing Mr. Ruhmer's apparatus last summer in Berlin, with which he succeeded in talking over a beam of light 4¼ miles in length, employing for this an arc lamp with a current of from 12 to 16 amperes.

At the Electrical Exhibition held in Madison Square Garden in May, 1899, Mr. Hayes showed an interesting experiment in this line. At one end of the Garden was placed a telephone before which a cornet was played, causing waves of current in the telephone circuit to be superimposed upon those in a neighboring arc light circuit; the light rays from this arc lamp were reflected across the Garden, where they were received in a parabolic reflector, in the focus of which was a glass tube containing carbon filaments. To this tube were connected the ordinary listening tubes, such as used with the Edison phonograph. The varying light falling upon the carbon caused variations of the temperature of the air inside the tube, reproducing perfectly the original sounds in the listener's ear. A bulb coated with lampblack and containing nothing but air may be used.

The slide which I now throw on the screen illustrates the arrangement of the apparatus employed by Mr. Ruhmer, and I take pleasure in presenting also several other important applications of selenium, which are the results of Mr. Ruhmer's painstaking investigations.

I hold here in my hand the latest form of Ruhmer's cell, which you observe resembles somewhat an incandescent lamp. The cell itself is placed inside of a glass globe from which the air is exhausted, and the terminals are attached to a lamp-base similar to that of the Edison incandescent lamp, this forming a most convenient method of mounting these cells.

In making selenium cells it is usual to wind two separate windings of wire (either copper, brass, German silver, or platinum) equidistant throughout their whole length; these windings being placed usually on slate, glass, mica or porcelain, and the selenium being spread evenly over the wires, forming an insulation between the two circuits. The Ruhmer cell which I have shown you employs copper wire wound on porcelain and placed in an exhausted glass bulb, as already described. Mr. Ruhmer also employs platinum wires wound on a cylinder of glass.

Considerable difficulty has been experienced heretofore

in employing selenium cells by reason of their being so susceptible to moisture, and it is this taking up of moisture which produces the electrolytic effect in the cell, which has enabled one to connect the cell with a galvanometer and, by merely focusing the light upon the cell, producing a current in the cell itself. This resulted in the designation of the "photo-electric cell."

Such an effect as this would not be present where the cell is placed inside of a vacuum, and this device of Mr.

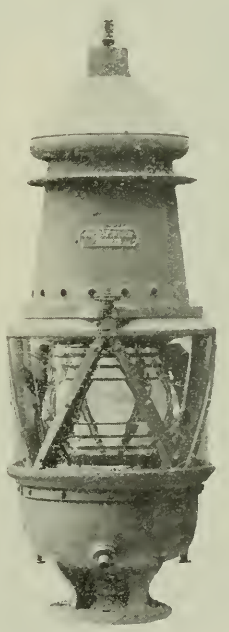


FIG. 11.—Buoy containing Pintsch gas and controlled by Ruhmer's selenium cell.

Ruhmer is a most important step towards the commercial development of it.

In the slide now on the screen (see *Fig. 11*) you will note an interesting application of Mr. Ruhmer's cell to the gas-buoy, such as is employed at sea. These buoys may contain a charge of compressed gas which will last from thirty days to six months and even a year.

It had been necessary up to the present for these buoys to burn both night and day on account of the impossibility of turning the gas off during the daytime. Mr. Ruhmer has placed one of his cells in the top of the buoy and connected it with a relay, a switching device and battery, by means of which when the sun rises in the morning the resist-

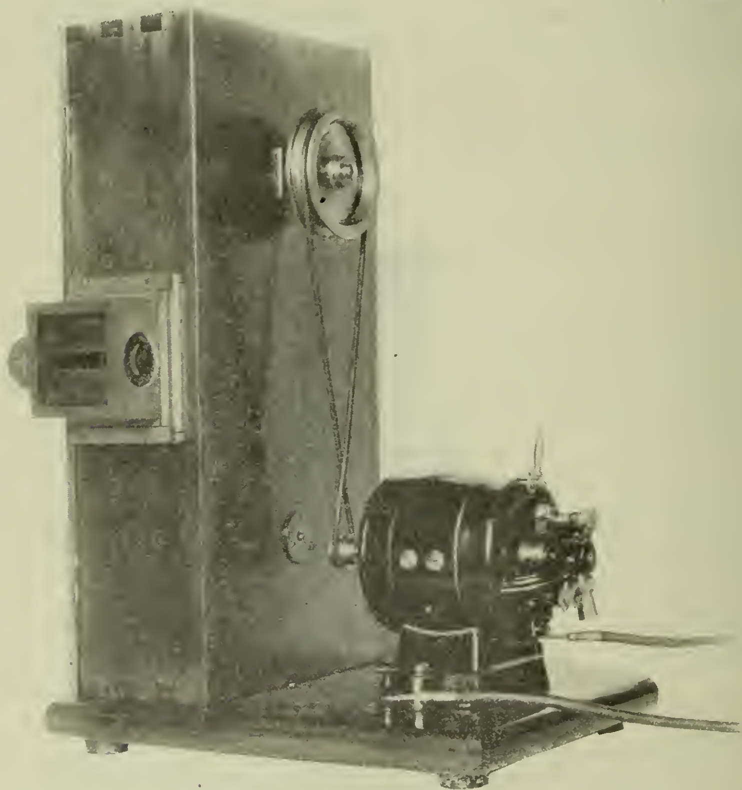


FIG. 12.—Ernest Ruhmer's photographophone (exterior view).

ance of the selenium cell is lowered, sending more current through the relay and operating the local circuit containing the switching device and battery which turns the gas off. As soon as night approaches, or in case of storm, the selenium increases its resistance and the opposite effect takes place, the gas being again turned on.

When I was in Berlin last August one of these buoys

had been in operation since the previous October, and Mr. Ruhmer has recently written me that it is still operating successfully, as are others which have been placed near Hamburg and in the Baltic Sea.

Mr. Ruhmer has built a piece of apparatus which he has called the "photographophone," which I consider one of the

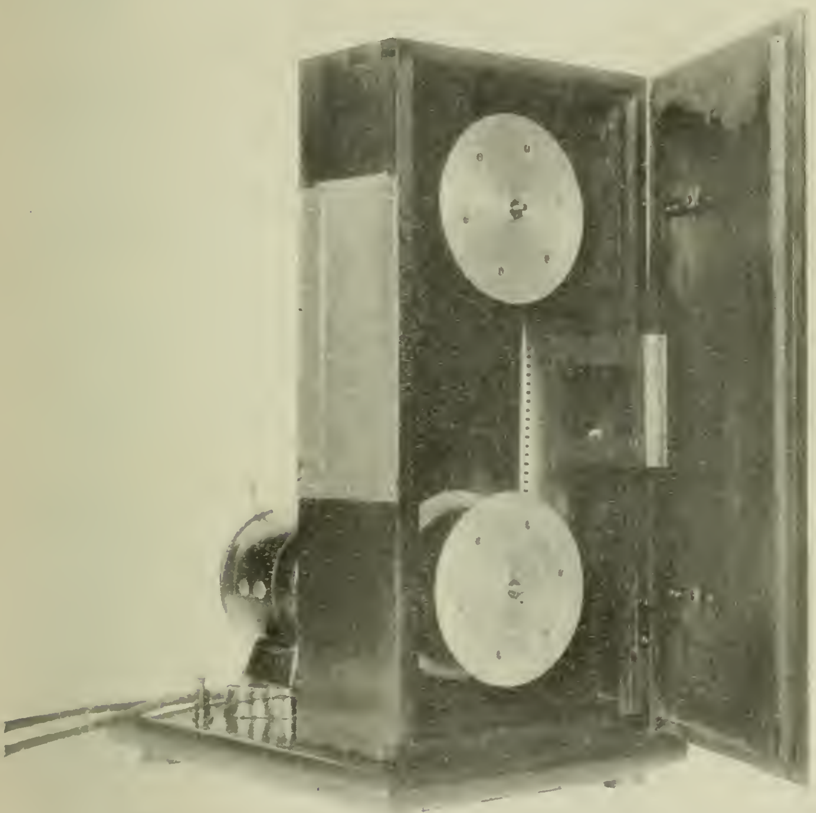


FIG. 13.—Ernest Ruhmer's photographophone (interior view).

most remarkable inventions which I have ever seen. The illustration of this is shown in *Figs. 12* and *13*.

I shall now throw on the screen a number of slides illustrating the construction and operation of this apparatus. It consists of a box containing a gelatine film, such as used in moving-picture machines. Back of the film he has placed

a selenium cell which is connected to a battery and telephones. These telephones may be at any distant point. In the front of the box is a cylindrical lens, and placed in front of the lens is an arc lamp and a telephone. When words are spoken or sung into the telephone the waves started up in the telephone circuit are superimposed on the circuit embracing the arc lamp, causing the light to vary in intensity. The light-rays pass through the cylindrical prism, fall in sharp white lines on the moving gelatine film on which they are photographed. When the pitch is high these striations are close together, and when the pitch is low they are broader and farther apart. The film after being developed is placed back into the box and then acts as a screen to cut off the rays of light passing through the lens. These rays are now quite constant, as the telephone transmitter has been removed and the arc burns steadily.

The rays after passing through the lens pass next through the gelatine film, and impinge upon the selenium cell in the back of the box, varying the resistance of the selenium in a degree corresponding to the amount of light admitted by the moving film.

The variation in the resistance of the selenium cells affects corresponding variations in current passing from the battery into the telephone, thus reproducing the original sounds spoken or sung into the telephone. I have myself operated this device and can verify the statement of the inventor, that, remarkable as it may seem, it does the work perfectly.

I hold in my hand a vial containing some "thermit," the wonderful properties of which were discovered by Goldschmidt. It consists of oxide of iron, such as one would get off a blacksmith's anvil or the rolls of a rolling-mill, mixed with powdered metallic aluminum. If a red-hot iron rod is thrown into this mixture nothing occurs; but by sprinkling a little barium preparation or some magnesium powder over the top of this mixture and applying a match immediately an extraordinary reaction takes place, producing a temperature of 5,400° F.; and if a kilo (2·2 pounds) of this substance is thus ignited the reaction which takes place

represents a mechanical equivalent of about 1,730 horse-power seconds, or about 1,274 kilowatt seconds.

I have here some samples of manganese, of chromium and ferro-titanium, all of which have been produced by this remarkable process; and I have seen some very interesting experiments in welding steel pipes, girder rails, etc., by means of this process.

It is claimed that a burglar might carry a small amount of thermit in his pocket, and on placing it on a steel safe would burn a hole through the safe, enabling him to insert his arm and extract the valuables. I myself have seen several safes which had thus been opened.

A company has been formed to exploit a substance known as "anti-thermit," which it is intended to mix with substances used as a heat-resisting lining of safes, and thus check any action of thermit.

It would be possible to insert a selenium cell in or near the safe so that the powerful light and heat produced by the burglar's attempt to open the safe in this manner with thermit, or even the light produced by his bull's-eye lantern, would affect the selenium cell and give an alarm to the police.

There are other applications of selenium for indication of the extinction of railway and ship signal-lights, and for various other purposes.

Those who are particularly interested in this subject I would refer to the paper of Mr. A. P. Saunders, in the *Journal of Physical Chemistry* for June, 1900, which, in addition to a large amount of valuable data, gives considerable of the bibliography regarding selenium.

SILOXICON, A NEW REFRACTORY MATERIAL.

E. G. Acheson, of Niagara Falls, N. Y., who discovered the process for making carborundum and that for making manufactured graphite, has discovered and patented a new compound to which he has given the name Siloxicon. It consists of carbon, silicon and oxygen, and if all the claims are supported it will be found that Siloxicon possesses physical and chemical properties of very great interest and importance to the field of metallurgy.

Siloxicon is the product of a new furnace that has been installed in the

plant of the International Acheson Graphite Works at Niagara Falls, N. Y. This furnace is about 30 feet long, 8 feet wide and is built to a height of about 6 feet when ready for operation. The raw materials used in the manufacture are ground coke and sand in proper mixture. One thousand electrical horse-power is applied to the furnace, and Siloxicon forms at a temperature ranging from 4,500° to 5,000°. With the present-size furnace the product is about 6 tons to a furnace. The walls of the furnace are of loose brick, no mortar being used in the building. The raw material is thrown into the furnace about a multiple set of flat cores, two or more in number. Siloxicon comes from the furnace in a loosely coherent mass and is then ground in a mill so as to pass through a No. 40 sieve, when it is ready for shipment in barrels.

Mr. Acheson describes Siloxicon as an amorphous gray-green compound when cold, and light yellow when heated to 300° F., or above ; very refractory to heat, insoluble in molten iron, neutral toward basic and acid slags, indifferent to all acids save hydrofluoric, unattacked by hot alkaline solutions and self-binding to such a degree that the use of a separate binding agent is not essential in forming it into crucibles, furnace linings, fire-bricks and such other articles as may with advantage be made from it. The various articles may be formed by simply moistening the pulverulent material with water, molding and firing, or a carbonaceous or other binding agent may be used if desired. To-day the greater part of metallurgical operations are conducted with high-grade fire clays, but these have been improved upon by the use of chrome, silica and magnesia. However, the best of these fall short of perfect results, either on account of their low melting-point or the reaction that occurs between the slags. Siloxicon is insoluble in metal, infusible at high temperature and neutral to clays, thus forming an ideal material for metallurgical work. It is also unoxidizable. As Siloxicon is made at a temperature ranging from 4,500° to 5,000°, it is evident that it is capable of withstanding any heat produced by flame or fuel combustion. For this reason it is believed that Siloxicon will be a valuable lining where oil fuel is used, for at present under this intense heat trouble is experienced in getting something to withstand it. While Siloxicon is made in a furnace similar to carborundum, it forms previous to the carborundum formation. In the manufacture of carborundum some Siloxicon is formed. but it is found outside the carborundum core, where the heat of the furnace does not reach the higher temperature necessary to the manufacture of carborundum.—*Iron Age.*

ALCOHOL MOTORS.

Alcohol motors are much used in Germany, especially for automobile purposes, the fluid, 90 per cent. pure, being sold at about 5 cents per quart. The motors have all the advantages of cleanliness, ease of starting and stopping, and the weight is only about one-half that of a portable steam engine of equal power. Six to 8 horse-power motors are sold at about $140 per horse-power, 10 to 12 for about $115, and 16 to 20 for about $90 per unit of power. Tests seem to indicate an average consumption per brake horse-power per hour of about 0·92 pound of 86 per cent. spirit, and about 0·81 pound of a mixture of one-fifth benzol and four-fifths 86 per cent. spirit.—*Iron Age.*

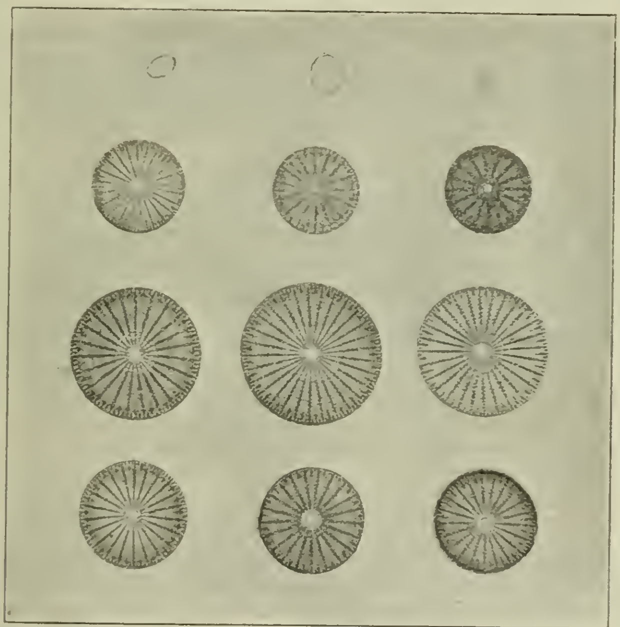
Section of Photography and Microscopy.

Stated Meeting, held April 4, 1903.

The Diatoms of Agar-Agar.

By Henry Leffmann.

Agar-agar, well known in the bacteriologic laboratory, is derived from several species of algæ growing in eastern Asiatic waters. It occurs usually in the form of filaments



Diatoms from agar-agar, prepared by Henry Leffmann; arranged and mounted by F. J. Keeley; photomicrograph by W. H. Walmsley.

about as thick as common straw. Its chief value to the bacteriologist is that it produces with water a jelly that does not melt at blood-heat, and can, therefore, be used for culture experiments at higher temperatures than can be used with common gelatin. It is analogous to the pectin of common fruits, and is not nitrogenous. It is used to a

limited extent as food, especially in the East, and is much employed in the large cities of the United States in the making of the cheaper ice-creams, especially the so-called "hokey-pokey" ice-cream sold by hucksters. It may also be used in some fruit jellies. It does not seem to be an objectionable article when used in moderate amount in these foods; in fact, as regards the ice-cream, the far more serious question is the liability of it to be made in dirty places and from dirty materials.

The detection of agar-agar itself when mixed with other vegetable or animal products would be difficult. Fortunately, the commercial article is always sprinkled with characteristic diatoms, which have attached themselves to the growing plant. The most important is *Arachnoidiscus Ehrenbergii*, a well-marked circular form, which does not live in the Atlantic Ocean or adjacent waters. By destroying the organic matter in any food article by strong oxidizing agents, the siliceous skeletons of the diatom are left uninjured, and can be easily recognized under moderate magnifying power.

A picture of forms obtained from a specimen of commercial agar-agar is appended.

Notes and Comments.

PRECIOUS STONES IN 1902.

A preliminary report submitted to the United States Geological Survey by Mr. G. F. Kunz, of New York, says that the year 1902 has been remarkable in precious-stone industry in America in a number of particulars, among which the following may be especially noted: The finding of a new locality for sapphires in Montana—a new creek, in the bed of which sapphires are found associated with gold, as in the Rock Creek region at Yogo Gulch, and on the Missouri near Helena; the further development of a new mine of blue sapphires in Fergus County; and the continued workings of the other two mines in the same State. Then comes the mining and development of the old beryl localities in Mitchell County, N. C., and the development of the beryl locality at Grafton, N. H. An amethyst mine has been opened in South Carolina, and two new amethyst deposits have been found in the State of Virginia. The mining of rubellite in San Diego County, Cal., continues, and a new deposit near Banner in the same region has been found. The further develop-

ment of chrysoprase in Tulare County, Cal., and the discovery of a new locality in Buncombe County, N. C., are to be noted. A deposit of vesuvianite (idocrase) has been discovered in Central California. The output of turquoise from eight or more Western localities continues, and it has been discovered at two localities in Alabama, the most easterly region yet known for that gem.

It has been the greatest year on record for the importation of diamonds, pearls and other precious stones. The imports, also, of topaz, both the true and the so-called Spanish, Saxon and Scotch varieties, of coral in delicate tints of pink, and of seed pearls and pearls in ropes, are worthy of remark.

The production of precious stones in the United States during 1902 is valued as follows: Sapphire, $115,000; beryl, $4,000; emerald, $1,000; tourmaline, $15,000; peridot, $500; quartz, $12,000; smoky quartz, $2,000; rose quartz, $200; amethyst, $2,000; gold quartz, $3,000; rutilated quartz, $100; agate, $1,000; moss agate, $500; chrysoprase, $10,000; silicified wood, $7,000; rhodolite, $1,500; garnet (pyrope), $1,000; amazon stone, $500; turquoise, $130,000; chlorastrolite, $4,000; mesolite, $1,000; pyrite, $3,000; anthracite ornaments, $2,000; catlinite (pipestone), $2,000.

This gives a preliminary total of $318,300 for 1902, as compared with $289,050 in 1901, and $233,170 in 1900.

SHIPBUILDING DURING 1902.

The returns of shipbuilding that are available for the year 1902 prove that although it has been a busy season among all the shipyards of the world, it does not reach in total output the figures of the year preceding. During 1902, 2,393 vessels of a total tonnage of 2,699,000 tons were launched, whereas in 1901, 2,192 vessels of 2,763,000 tons were launched, an increase in the number of vessels, but a decrease in the total tonnage of 64,000 tons. As usual, considerably more than half, in fact 60 per cent., of the world's output was built in British shipyards, from which, during the year, was launched a total of 1,368 vessels of 1,619,000 total tonnage. Next to Great Britain in amount of construction came the United States and Germany. There were launched in this country in 1902, 162 vessels of 315,000 tons, which is a decrease of 10,000 tons compared with the previous year. Germany launched 259 vessels of 272,000 tons, an increase during the year of 6,000 tons.

The prosperity of the shipping trade has been practically worldwide, the tonnage launched in France having risen from 32 vessels of 86,000 tons in 1901, to 102 vessels of 190,000 tons in 1902. Italy, Japan, and Holland all show a considerable increase. There is not much to be said regarding the character of the ships that were built, for there have been no radical changes either in the form of hull or in motive power. Perhaps the most interesting feature of the statistics is the increase in the number of sailing ships, the proportion of sailing to steam tonnage built in British yards having risen from 2·2 per cent. in 1900 to 3·9 per cent. in 1901, and 5·6 per cent. in 1902. Unquestionably the most interesting sailing ship of the year was the seven-masted schooner "Thomas W. Lawson." The steam turbine is not making the rapid advance in the mercantile marine that was expected, although it is being applied to a few passenger steamers and steam yachts. The most inter-

esting steamship of the year was, of course, the new North German Lloyd liner "Kaiser Wilhelm II," of 26,000 tons displacement and 24 knots speed.—*Scientific American.*

NEW TYPE OF FILE FOR GUN METAL.

A new type of file, specially devised for working upon gun metal, has been introduced into the engineering department of the Chemin de Fer du Nord, France. The feature of this tool, which distinguishes it from the general type of file, is a series of shallow channels which cross its face diagonally at an angle of 30° and placed about ½ inch apart. The raised portions of the surface of the file between these channels are occupied by the teeth of the tool. The advantages of the file are that it clogs less rapidly, and can easily and quickly be resharpened on the sand-blast, while it increases the work of the engineer who uses it in connection with gun metal filing by 30 per cent.—*Scientific American.*

NICKEL-STEEL ALLOY.

It was discovered some months ago that a nickel-steel alloy, containing 36 per cent. of the former metal, has a coefficient of expansion far below that of wrought-iron, it being only 0·0000005 for 1° F. It is also said to resist oxidation remarkably well. Recent investigations have shown the added fact that by the addition of small quantities of iron or nickel to the least expansive alloy it is possible to form an alloy having almost any desired coefficient of expansion. In this way "planite" is made, having the same coefficient as platinum, and also, of course, as glass. This new substance bids fair to supplant platinum (which has become far more expensive than gold) in the manufacture of incandescent lamps, where platinum terminals now pass through the glass.—*Iron Age.*

Book Notices.

Conductors for Electric Distribution: Their materials and manufacture, the calculation of circuits, pole-line construction, underground working and other uses. By F. A. C. Perrine, A.M., D.Sc., etc. 8vo, pp. viii + 287. New York: D. Van Nostrand Company. London: Crosby, Lockwood & Son. 1903. (Price, $3.50 net.)

The author presents in this work the clarified results of an experience of more than ten years as a manufacturer and consulting engineer. The fourteen chapters of the work appear to cover the subject in a most thorough manner. W.

Jahrbuch der Elektrochemie. Berichte über die Fortschritte des Jahres 1901. Herausgegeben von Dr. Heinrich Danneel. VIII Jahrgang, pp. viii + 725. Halle a S. Verlag von Wilhelm Knapp. 1902. (RM. 24.)

The rapid progress of this branch of physical chemistry is amply certified by the imposing volume of more than 700 pages here entitled, in which is

concisely recorded the noteworthy discoveries and applications of the science which appeared during the year 1901.

The present volume follows in its arrangement of contents the general features of those which have preceded it.

Part I is devoted to the scientific side of the subject. It treats of methods and apparatus of research, theories, solutions, electrical energy, polarization and electrolysis, radiant energy and chemical energy. Part II treats of the applications of the science; the production of electrical energy by various types of generators; inorganic and organic electro-chemical products; apparatus employed in electrolytic and electrothermic processes. The volume closes with a review of books of the year and an elaborate index. W.

Einrichtungen von Elektrolytischen Laboratorien unter besonderer Berücksichtigung der Bedürfnisse für die Hüttenpraxis. Von H Nissenson. (Mit 32 in den Text gedruckten Abbildungen.) Halle a/S. Verlag von Wilhelm Knapp. 1903. (M. 2.40.)

Die Herstellung von Metallgegenständen auf Elektrolytischem Wege und die Elektrogravüre. Von Dr. W. Pfanhauser. (Mit 101 in den Text ged. Abbildungen.) Halle a/S. Verlag von Wilhelm Knapp. 1903. (M. 7.)

The works above named constitute respectively volumes IV and V of the series of "Monographien über angewandte Elektrochemie," which issue at regular intervals from the press of Wilhelm Knapp.

Vol. IV treats of the subject under two general heads. Part I takes into consideration the theory and principles of electrolysis, while Part II is devoted to the description of a number of noteworthy installations of electrolytic laboratories, principally in various educational institutions. These are accompanied by illustrations.

Vol. V treats of the methods employed in the galvanoplastic reproductions in metal, including the manufacture of metallic powders and the production of foils and tubes by electrolytic methods, and the present state of the art of electrogravure. W.

Elektrometallurgie des Nickels. Von Dr. W. Borchers. Mit vier in den Text ged. Abbildungen. 8vo, pp. 36. Halle a/S. Verlag von Wilhelm Knapp. 1903. (M. 1.50.)

Borchers' work treats not only of the electro-deposition of nickel on other metallic surfaces, but also of the electro-metallurgical separation and winning of nickel from its more or less complex ores. The latter phase of the subject is comparatively new and its treatment appears for the first time in book form. W.

Steam-Power Plants: Their design and construction. By Henry C. Meyer, Jr., M.E, 8vo, pp. 159. New York: McGraw Publishing Company. 1903. (Price, $2.00.)

The author explains that this book was written to give information to owners or managers of manufacturing plants or buildings requiring power installations, since they are from time to time called upon to specify or purchase the machinery needed for the proper equipment of their buildings with

a view to efficiency and economy in operation. While it is true wisdom to employ an expert to prepare plans and specifications for any important power-plant, it is also true that the greater number of steam installations will be made under the direction of men who are experienced in the details of manufacturing in their special lines, yet make no claim to expert knowledge in power-plant engineering. To such the author hopes that the information presented in his book will prove suggestive and valuable, as well as to the engineer, architect and student who desire general information on the subject treated.

To the expert it claims only to present in accessible and convenient form data useful in the practice of his profession. W.

Storage Battery Engineering: A practical treatise for engineers. By Lamar Lyndon, B.E., M.E., etc. 8vo, pp. vii + 382. New York: McGraw Publishing Company. 1903. (Price, $3 00.)

This is a practical work intended for the electrical engineer who is called on to design and install storage battery equipments, or who has a battery power plant under his care. The first part deals with the storage battery, its construction, action under various conditions, deterioration and the causes of the observed phenomena. The treatment is almost entirely physical, the chemical theory involved being very limited in extent and elementary in character. The second part covers all the apparatus, devices and methods used in the application and control of batteries. The various systems of boosters are described and an analytical discussion of each type is given. Some of the most important systems are illustrated by practical examples. Altogether it forms a complete compendium for the engineer to which any question that may arise in storage-battery practice may be referred and satisfactorily solved. W.

Franklin Institute.

[*Proceedings of the Stated Meeting held Wednesday, May 20, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 20, 1903

President JOHN BIRKINBINE in the chair.

Present, 88 members and visitors.

Additions to membership since last meeting, 27.

The death of Mr. Theodore D. Rand, Vice-President of the Institute, was reported, with the action taken in connection therewith by the Board of Managers. An election was held to fill the vacancy, which resulted in the choice of Mr. James M. Dodge.

Mr. Howard W. DuBois, mining engineer, Philadelphia, presented a communication entitled "Reconnaissance Methods of Surveying in a Mountainous District." The speaker described and elucidated, by means of diagrammatic views, some new and interesting methods of applying photography for this purpose, and in addition to the technical illustrations, exhibited a series

of finely executed and artistically colored lantern photographs of the mountainous scenery of British Columbia.

Mr. Harrison Souder, Cambria Steel Company, Johnstown, Pa., followed with a paper on "Cuba of To-day: Engineering Notes and Impressions." The speaker gave an account of his observations made during a recent professional trip through the island, illustrating his remarks by showing a number of lantern photographs of interesting engineering works, mining operations and other subjects of general interest.

Dr. Samuel P. Sadtler followed with an informal discussion—principally from the chemical viewpoint—of the principles of the art of rendering wood, intended for structural uses, "fire-resistant," and commented on the results of a recent investigation of the Ferrell process by the Committee on Science and the Arts of the Institute. Dr. Sadtler's remarks were illustrated by the presentation of a series of samples of various building woods, treated and untreated, which had been subjected to compression and breaking tests by Mr. W. P. Taylor, Engineer-in-charge of the Municipal Laboratory. The interesting fact was brought out by those tests that the fire-proofing treatment by the Ferrell process did not appreciably impair the strength of the materials.

The thanks of the meeting were tendered to the speakers of the evening and the meeting was adjourned.

WM. H. WAHL,
Secretary.

Sections.

(*Abstracts of Stated Meetings.*)

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, April 2d. Dr. E. Goldschmidt in the chair. Present, 54 members and visitors.

The Executive Committee announced the appointment of the following to serve as officers of the Section for the current year, viz.: President, James Christie; Vice-Presidents, Prof. F. L. Garrison and Wm. R. Webster; Secretary, G. H. Clamer; Conservator, Dr. Wahl.

The paper of the evening was presented by Mr. Clamer. Subject: "The Study of Alloys Suitable for Bearing Purposes." The author illustrated his remarks with the aid of a large number of photomicrographs and tables.

The discussion which followed was participated in by Messrs. Paul Kreuzpointner, A. E. Outerbridge, Jr., Robert Job and the author. (Paper and discussion will appear in the *Journal.*)

G. H. CLAMER,
Secretary.

PHOTOGRAPHIC AND MICROSCOPIC SECTION.—*Twenty-second Stated Meeting*, April 4th. Dr. Henry Leffmann in the chair. Present, 48 members and visitors.

Dr. Leffmann and Mr. F. J. Keeley presented a joint contribution on Agar-agar. Dr. Leffmann gave an account of the origin and uses of the plant, and Mr. Keely described and exhibited under the microscope the characteristic forms of diatoms found therein, by which it can be identified when used as a substitute for gelatin.

Mr. U. C. Wanner presented a communication on "Some Experiments in Stand or Tank Development," which was illustrated by the exhibition of a number of negatives and prints made from negatives developed in tanks with dilute developer.

Mr. Martin I. Wilbert addressed the meeting on "The Use of Lantern Slides as an Aid in Object Teaching." The speaker illustrated the subject by showing a number of slides (loaned by Prof. Jos. P. Remington) exhibiting botanic and pharmacologic objects colored by students of the St. Louis College of Pharmacy.

Mr. Howard W. DuBois exhibited a number of artistically colored slides and made some remarks on the method of coloring.

Dr. Leffmann exhibited a number of slides representing typical desert vegetation.

M. I. Wilbert,
Secretary.

Physical and Electrical Sections.—*Meeting*, Thursday, April 23d. Mr. Jesse Pawling, Jr., in the chair. Present, 22 members and visitors.

A paper entitled, "On the Design of Direct-Current Dynamo-Electric Machines," by Mr. Cecil P. Poole, of New York, was read by title and was ordered to be printed and circulated in advance of the next meeting for discussion. Dr. E. F. Roeber addressed the meeting on "Electrical Dissociation," which was announced as the subject for discussion. The following members participated, viz., Dr. E. Goldsmith, Prof. Amos P. Brown, Messrs. C. J. Reed, Carl Hering and C. H. Bedell. W.

Section of Photography and Microscopy.—*Twenty-third Stated Meeting*, held Thursday, May 7, 1903. Dr. Henry Leffmann in the chair. Present, 49 members and visitors.

The first communication of the evening was a description and practical demonstration of the uses of platinum papers, by Mr. John Bradley. In the course of his demonstration the speaker developed a number of prints, illustrating the ease with which papers of this kind may be handled.

Dr. Henry Leffmann followed with a communication on "A Bacterial Lamp," which was an interesting abstract from a paper of Herr Malisch in a recent impression of the *Oesterreichische Chemiker Zeitung*.

Mr. J. W. Ridpath exhibited a number of miscellaneous lantern photographs of subjects of local interest.

M. I. Wilbert,
Secretary.

Mining and Metallurgical Section.—*Stated Meeting*, Thursday, May 14, 1903. Mr. John Birkinbine in the chair. Present, 62 members and visitors.

The paper of the evening was presented by Mr. Charles Kirchhoff, Editor of the *Iron Age*, New York. Subject: "The Utilization of Blast Furnace Gases for the Generation of Power." The paper was fully illustrated by means of lantern photographs, and will appear in the *Journal* with discussion.

Wm. H. Wahl,
Secretary pro tem.